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LIST OF PLATES.

PLATES.		PAGE.
I.	Microscopic Structure of the Pitchstones of Arran	1
II.	Fossil Ferns	49
III.	*Rostellaria Pricei*, H. Woodw., Grey Chalk, Folkestone	97
IV.	*Squaloraia polyspondyla*, Agassiz, Lower Lias, Lyme Regis	145
V.	Oolitic Coniferæ from Solenhofen...	193
VI.	Tylose in Tertiary Wood from Thanet	241
VII.	Chart of a portion of North-West Greenland	289
VIII.	Plan of the Sea-shore showing the Position of the Masses of Meteoric Iron found at Ovifak, Greenland	355
IX.	A New Arachnide from the Coal-measures, Lancashire...	385
X.	Palæozoic Crustacea	433
XI.	Sections to Illustrate Mr. Tylor's Paper on the Formation of Deltas ...	485
XII.	Graptolites from the Moffat Group	501
XIII.	*Orithopsis Bonneyi*, Lower Greensand, Lyme Regis	529
	Satyrites Reynesii, Tertiary, Aix in Provence	529

LIST OF WOODCUTS.

Coast-section of a part of New Colwyn Bay	16
Both sides of a Striated Stone from the Colwyn Blue Clay	16
Roche moutonnée in Anglesey, looking leeward or down-stream	19
Distant view of Moel-y-Tryfan, from near Bangor	26
Section of Marchlyn-mawr	22
Cardiocarpon Lindleyi, Carr., Coal-measures, Falkirk	55
Cardiocarpon anomalum, Carr., Coal-measures, Derbyshire (?)	57
Araucarioxylon (*Pinites*) *Withami*, Kraus., Coal-measures, Edinburgh... ...	58
Pine-wood from Wealden at Brook, Isle of Wight	58
Pothocites Grantoni, Paterson, Coal-measures, Edinburgh	58
Pyrites Deposit, Buitron Mine, in the Province of Huelva, in Spain	60
Esquimaux Knife from West Coast of Greenland	73
Endoceras proteiforme, Hall, Coniston Series, near Ambleside	103
Araucarites Häberleinii, Dyer	151
Araucarites sphærocarpus, Carruthers	151
Longitudinal Section of Scale of *Araucaria Bidwilli*	152
Map of Strata at Whitberry Point, East Lothian...	162

PAGE
Section at Whitberry Point, East Lothian... 162
Water-worn Teeth of *Carcharodon* from the Suffolk Crag 248
Large Tooth of *Carcharodon megalodon*, Agassiz 249
Fossil Human Skeleton found in the Cavern of Baoussé-rousse 273
Sections to Illustrate Mr. Törnebohm's Theory of the Swedish Åsar 307
Sketch Map of the Malar Basin, showing the direction of the Åsar 308
Section at Welcome Rush, Australia 336
Inland Ice abutting on Land, Greenland 362
Inland Ice extending into the sea, and terminating in a steep edge, Greenland ... 363
Inland Ice abutting on the bottom of ice-fjord, Greenland 364
Inland Ice abutting on a Mud-bank, Greenland 364
Crinoidal Remains associated with Casts of the Stems of *Cupressocrinus*... ... 388
General Section of Drifts in the Central part of the Lake District 402
Sections of Roslyn Hill Clay Pit 404, 407
Plans of Roslyn Hill Clay Pit 405, 407
Section in Greenland before any modern denudation has taken place 424
Section in Greenland along a modern Mountain Stream 425
Hemiaspis limuloides, H. Woodw., L. Ludlow, Leintwardine 435
Pseudoniscus aculeatus, *Exapinurus Schrenkii*, and *Bunodes lunula* 436
Head-shield of *Hemiaspis speratus*, Salter... 437
Head-shield of *Hemiaspis horridus*, H. Woodw. 437
Head-shield of *Hemiaspis Salweyi*, Salter... 438
Tubes of *Ortonia conica*, Nich., growing on valve of *Strophomena alternata* ... 447
Succession of Strata at Ekkorfat, Greenland 449
Series of Strata below Atanekerdluk 453
Bituminized Tree-stem from Atanekerdluk 456
Series of Strata at Atanekerdluk 457
The three largest Meteoric Stones, Greenland 462
Range and Evolution of the several Orders of Crustacea in Time 568

T. Fiddian lith

MICROSCOPIC STRUCTURE OF THE PITCHSTONES OF ARRAN.

THE

GEOLOGICAL MAGAZINE.

No. XCI.—JANUARY, 1872.

ORIGINAL ARTICLES.

I.—On the Microscopic Structure of the Pitchstones of Arran.

By S. Allport, F.G.S.

(PLATE I.)

THE Island of Arran has long been celebrated among geologists for the variety and extensive development of its igneous rocks. The basaltic group is well represented in its various forms of structure and modes of occurrence; the more highly silicated series by felsites and porphyrites, forming dykes and huge amorphous or columnar masses; while the glassy varieties are illustrated by dykes and veins of pitchstone. All these rocks may be readily studied in the small area comprised within the southern half of the island, the greater part of which consists of eruptive rocks, and sandstones of the Carboniferous period. It is among these sandstones that most of the igneous rocks have been intruded. Some, however, are evidently interbedded and contemporaneous, forming great sheets of melaphyre between the Carboniferous strata.

In the northern half of the island the geological features are entirely different. The whole of the central portion is occupied by granite, rising here and there into mountain-masses with sharp serrated peaks. The granitic district is roughly circular, with a diameter of seven to eight miles, and is completely surrounded by a band of Silurian slates; the latter are bordered on the north, east, and south by Old Red Sandstone, or Lower Carboniferous rocks. Trap dykes frequently occur here also, and there are dykes of pitchstone in the granite.

A visit to the island in June last enabled me to collect a good series of specimens of the intrusive rocks, including several very interesting varieties of pitchstone. Of these I have prepared many thin sections for microscopic examination; and as few are aware of the singular beauty of their structure, I propose to describe the most characteristic varieties in the present communication.

In all the specimens examined, the mass of the rock is found to consist of a structureless glassy base, in which may be seen a variety of crystalline minerals, some of microscopic size, others much larger, and porphyritically imbedded. A glassy material of similar character also occurs not unfrequently in basaltic rocks of all ages, but in much smaller quantities; when it greatly predominates, as in the pitchstones, etc., it, of course, gives a vitreous aspect to the rocks; in all cases it appears to be the uncrystallized residuum of the original fluid or viscid mass; it does not exhibit double refraction. When examined with a sufficient magnifying power (300 to 600), the microscopic forms are found to be either distinct crystals or rounded granules; the former are generally acicular prisms, and in the following descriptions will be frequently called belonites;[1] and the entire group of microscopic products will be included under the term microlite, both being convenient terms, employed by Zirkel in his description of the vitreous rocks.[2]

On the Corriegills shore north of Clauchland Point, a vein of pitchstone from twelve to thirteen feet thick occurs in the face of the cliff not far from the foot of Dun Fion. At first sight it appears to lie between the beds of Carboniferous sandstone; it is, however, fortunately exposed for some distance, and a careful examination shows that it cuts gradually, yet distinctly, across the strata, and is therefore clearly intrusive. Another vein of quite similar pitchstone occurs at a higher level in the same series of sandstones of the Clauchland hills. It is a dark greyish-green vitreous rock with a dull resinous lustre, in which are scattered many small roundish grains of a pale yellow substance, and in some specimens there are a few small crystals of felspar and quartz.

A thin section, examined under the microscope with a one-inch objective, is seen to consist of an amorphous glassy base, containing numerous long slender prisms of a green pyroxenic mineral; the latter are occasionally isolated, but generally form the axes to which are attached innumerable minute pale green crystals, arranged in exquisitely beautiful groups; some wonderfully like fronds of ferns, others bearing the closest resemblance both in form and colour to some of the microscopic freshwater algæ; in fact, the field of view appears to be crowded with minute ferns, and the most elegant sprays and tufts of *Batrachospermum* (Plate I. Fig. 1). The glassy base has a pale yellowish tint in the open spaces between the groups; but under a higher power the colouring matter is resolved into a mass of translucent granules and minute crystals, the latter being much smaller than the belonites which form the fern-like groups. A comparison of many specimens, affording gradations in size, shows clearly that all these crystalline particles consist of the same pyroxenic mineral as the larger prisms which form the axes. It is worthy of remark that the tufts and aggregations of belonites are invariably surrounded by a border of clear colourless glass (see Fig. 1). Placed between crossed prisms, the section is, if possible, still more beautiful; the tufts and sprays then appear to be formed of bright gold powder on a perfectly black ground, with fine brilliant dust scattered in the dark spaces between the groups. The glassy base is a single refracting substance, and therefore dark be-

[1] βελόνη, "a needle." [2] Zeitschr. d. deutsche. geol. Gesel. 1867.

tween crossed prisms; the pyroxenic belonites, on the contrary, possess double refraction, and exhibit colours.

In one of the specimens from the Clauchland Hills the appearance is somewhat different: in the greater part of the section the glassy base is clear and colourless, the needles of pyroxene are sharply defined, and the plant-like forms also occur, but are here broad leaf-like expansions of green colouring matter, which is not resolved by an $\frac{1}{8}$-inch objective into anything like structure; nevertheless, it is not clear and transparent, and might possibly be resolved under a still higher power. This mode of occurrence would appear to represent the first stage of separation of the ferruginous from the other silicates of the base. The grains seen in the specimens are spherical, or egg-shaped bodies of a yellow substance, which polarizes light and exhibits a minute radial structure; some contain crystals of felspar, or short prisms of augite, also radiating from the centre, and not unfrequently extending beyond the circumference into the glassy base (Fig. 1). These spherules are clearly not secondary formations filling cavities, like the zeolites in other rocks, but are evidently related to the spherolites common in several varieties of perlitic pitchstone; it is a remarkable fact, that although they are clearly and sharply defined, yet the fern-like groups and other crystals frequently traverse the spheres as well as the base, penetrating both indifferently; their formation has not interfered in any way with the general texture of the rock; in other words, the crystalline forms are grouped, or distributed, without any relation whatever to the presence of the spheres.

Besides the forms just described, crystals of felspar, quartz, augite, and magnetite are porphyritically imbedded in the base; although comparatively rare in the rock from this locality, they are very numerous in others, and as their character and mode of occurrence is precisely the same in all the specimens examined, the following description will apply to the other varieties.

The felspar crystals are of two kinds, readily distinguished from each other by their action on polarized light; when examined in the polariscope, some are seen to be finely striated, or striped with coloured bands, indicative of the laminated structure of the triclinic group; others are of one colour only, or in the case of twins have two colours, sharply divided by the plane of junction of the two halves (Fig. 4). These crystals are orthoclase, and agree in their optical characters and fractured condition with the sanidine of many trachytes; they occur far less frequently than the former.

The two kinds of felspar have frequently grown together in one group, which may appear perfectly uniform in ordinary light, but in the polariscope is at once resolved into a number of separate crystals, with their axes at various angles, often penetrating each other, but each one sharply defined by a difference in shade or colour; this is due to the position of the optic axis relatively to the plane of polarization (Fig. 5). In very thin sections the crystals exhibit little or no colour, only dark and light shades, but when thicker they display fine colours. Some of the crystals are completely and regularly formed, exhibiting in section well-defined angles and edges; many of them are, however, imperfect, and not a few are mere fragments, probably broken by the flowing movement of the mass while still in a viscid state; but of this motion there is better evidence in certain peculiarities of structure, to be noted presently.

The felspar crystals frequently contain cavities, many of which are filled with portions of the glassy base and its characteristic contents; they are generally more or less rectangular in form, and often lie in rows parallel with the sides of the prism.

Crystals of augite and magnetite are sometimes imbedded in the felspar, it would therefore appear that this mineral was the last to crystallize.

The quartz is clear and transparent; it occurs in the sections in hexagonal or rhomboidal forms, and also as short prisms terminated by pyramids. The outlines are generally more or less rounded, sometimes completely so, but very frequently there are one or two well-defined edges and angles, the other sides presenting a peculiar rounded and indented appearance. This is well seen in Figs. 8, 9, and 10, which accurately represent three imperfectly formed crystals containing cavities filled with portions of the base. There are not only cavities inclosed in the quartz, but the indentations frequently open out into channels extending into the interior; some are proportionately much longer than those figured, while others show clearly how many of the cavities were formed. Fig. 12 exhibits an extension of the base into a quartz crystal through a narrow opening in the edge, and it is evident that a slight addition to the quantity of silica would close the aperture and produce a very characteristic form of cavity. Although these cavities vary in size and shape, most of them have a regular rhomboidal form, corresponding with that of the crystal (see Fig. 11); and it will be seen that Fig. 12 would afford an equally good example if the opening were closed.

The sides of the longer channels which penetrate the crystals are rounded, and sometimes bent into folds, forming flexures and curves which could only have been produced when the quartz was in a plastic state. It is evident from these facts, that the quartz crystallized out from the surrounding matrix, and also that the crystals were at one time small masses of plastic silica, which gradually assumed a crystalline form, and became perfect or imperfect, according as the conditions were more or less favourable.

It is important to observe that this mode of occurrence in the pitchstones is equally characteristic of the quartz crystals in the quartziferous porphyries, but that it is quite different from that which obtains in granite. It would appear, therefore, that the conditions under which the latter was formed must also have been different, and as the former are unquestionably true eruptive rocks, it may well be that those geologists are not far wrong who hold that in most cases granite is a metamorphic rock.

The augite has a clear transparent green colour, and occurs in well-formed crystals and irregular grains, but the former are rare; it is generally imbedded in the base, sometimes in the felspar also.

The total absence of dichroism is sufficient to distinguish it from hornblende.

The magnetite occurs, as usual, in opaque black grains, and is found in the augite and felspar crystals, and also in the base.

Drumadoon Point, on the west coast of the island, is a bold, rocky headland of quartz porphyry, exhibiting on its seaward face a magnificent group of lofty columns, which rest perpendicularly on beds of Carboniferous sandstone. On the shore, at the base of the cliff, there is an intrusive mass of quite similar rock, together with numerous dykes of basalt; the latter cut through the sandstones and porphyrites, and extend upwards through the great vertical columns. Northwards, towards Tormore, the dykes become still more numerous, and at one point, the side of an immense dyke of quartz porphyry forms a cliff rising abruptly from the water's edge. Immediately to the north, the shore is completely seamed by great dykes of basalt, porphyrite, felsite, and pitchstone. One large dyke, sixteen yards wide, is composed of basalt on one side and pitchstone on the other; in other cases, the sides are formed of basalt and the centre of pitchstone; in many places the latter has been altered to *hornstone* (so-called) for some little distance from the line of contact with the sandstones. One of these dykes just north of King's Cove consists of a greenish black porphyritic pitchstone, containing numerous small crystals of glassy felspar and quartz; the fracture is sub-conchoidal, lustre vitreous. Some parts of the rock exhibit numerous parallel stripes of a lighter colour, which pass as bands through the mass of the rock, their direction being parallel with the sides of the dyke. Under a one-inch objective, the texture is seen to differ considerably from the specimens described above. The base is a pale brown glass irregularly mottled with clear colourless spaces, and crowded in every part with slender pale green belonites and minute granules; they are not arranged in groups, as in the other varieties, but are evenly distributed throughout the mass, and for the most part lie with their long axes in a direction more or less parallel with the light-coloured bands. Porphyritically imbedded in this base are a number of crystals of felspar and quartz, a few of augite, and a few grains of magnetite.

To the sides of some of these crystals the belonites have attached themselves by one end in great numbers, projecting at right angles from the surface, or crossing each other in various directions. As the microlites of the base usually lie with their long axes more or less parallel, the general appearance is that of a stream of particles flowing in one direction; but when a crystal of felspar or quartz stands in the way, the stream is divided, the belonites appear to be diverted to either side, arrange themselves with their axes parallel to the sides of the obstacle, then sweep round it, and are again united in a direct course on the opposite side. This remarkable structure is well represented in Fig 13, which shows a group of compound felspar crystals, augite, and black grains of magnetite, surrounded by streams of belonites. The small group of augite crystals partly penetrates the felspar, and the sides of the latter are thickly studded with belonites. This stream-like arrangement of the smaller particles clearly indicates that the mass of the rock remained in a viscid state after the formation of the crystals; in all probability it is mainly due to the flowing movements of the lava previous to its consolidation. A similar structure is common in trachytic, and other volcanic rocks, and also occurs to a slight extent in some of the older melaphyres.

The varieties of texture in the striped pitchstones are extremely interesting, and deserve careful study, as they present peculiarities not to be found in other kinds of igneous rocks. In a specimen taken from a dyke about a mile south of Tormore, the striped appearance is due to the occurrence of numerous parallel bands and lines of a lighter colour than the mass of the rock, and an examination of thin transparent sections shows not only the nature of the bands, but that they also exist in microscopic proportions; for in one section, three quarters of an inch in diameter, there are no less than twenty-two light and dark coloured bands alternating with each other. The dark bands consist of a pale brown glass, containing a few tuft-like and stellate groups of small green crystals, while the pale stripes are of clear colourless glass, in which are to be seen numerous belonites and small pellucid granules; these are, however, much larger and fewer in number than the microlites forming the colouring matter of the brown bands. There is no tendency to cleave in the direction of the bands, and it is evident that the structure is quite different from the foliation of the crystalline schists; the rock is simply a continuous homogeneous glass, in which the devitrified or crystalline particles have arranged themselves in alternate layers characterized by differences in texture only; mineralogically, there is no difference whatever. Fig. 2 is a very successful attempt to represent the structure here described. A banded pitchstone from a dyke in the granite south of Cior Mor has a very similar structure.

A short distance from the dyke just described there is another of great interest; it is sixteen yards wide and strikes in a N.N.W. direction from the sea across the shore, and then rises straight up the face of the cliff through the sandstones, which form a smooth wall on each side. The west side of the dyke contains a band of *hornstone*, one foot thick, in contact with the sandstone, then several feet of pitchstone, the remainder being basalt; in one place a strip of sandstone has been caught up between the basalt and pitchstone and baked to a hard quartzite. This pitchstone exhibits a very different texture from the one just described; it consists of a yellowish-brown base, in which a few acicular pyroxenic crystals are arranged in stellate groups at some distance apart. Like others previously described, these groups are bordered by a clear space surrounded by the coloured glass, which forms a re-entering angle between the rays, the appearance being that of a bright star of five or six pointed rays. See Fig. 3.

The *hornstone* so frequently mentioned by Bryce in his "Geology of Arran" is simply altered pitchstone; a specimen taken from the side of this dyke exhibits under the microscope the characteristic structure of the unaltered rock; the quartz crystals are the same in every respect, but the felspar is no longer transparent, and the clear green belonites have lost their colour, and appear as yellowish-brown specks.

On the south-east slope of Goatfell, above the woods surrounding Brodick Castle, there are some blocks of a magnificent porphyritic pitchstone, of a very different character from any of the preceding. They lie in the bed of the carrier, which conveys water from the mill dam. The rock was not found *in sitû*, as the ground is here very unfavourable for examination, the mountain side being covered with débris from the higher granitic masses and thickly coated with turf.

The matrix is a greenish-black glass of dull lustre, crowded in every part with large crystals of glassy felspar, some of which are half an inch in length. Quartz crystals are also abundant. As the base is very finely granular, it requires a power of 500 for its examination, and is then seen to consist of a colourless transparent glass crowded with belonites of nearly uniform size; they are straight prisms $\frac{1}{1000}$ of an inch long by $\frac{1}{10000}$ broad, and intermingled with them are numerous minute granules.

These microlites are very regularly distributed throughout the glass, and lie at all angles, except when near one of the larger crystals, when their long axes at once assume a uniform direction, and they appear to bend round it. There are in addition many small crystals of augite about the $\frac{3}{100}$ of an inch long, and a few grains of magnetite. Lastly, there are the large felspar and quartz crystals, and a few of augite porphyritically imbedded in the matrix.

The felspar is chiefly triclinic, but orthoclase is also present. The crystals are, as usual, penetrated by the augite and magnetite, but in this rock they are especially remarkable for the large amount of the matrix inclosed in their cavities. Some are little more than skeletons of felspar, the whole of the interior being completely honeycombed with cells filled with the matrix just described, or with a brown glass, the latter sometimes predominates. Fig. 6 is a crystal of triclinic felspar, as seen in a thin section. During the process of grinding, the mass of the crystal was found to be similarly filled with brown glass.

In other crystals the cavities are arranged parallel with the sides, forming a broad band near the surface, the central part being clear felspar with only a few detached cavities.

It is evident that the chemist would be completely misled in an examination of these crystals, and it may be well to point out that, although this is certainly an exceptional case as regards the quantity of foreign matter, still the occurrence of various minerals in the constituents of igneous rocks is so common, that it is quite sufficient to account for many of the discrepancies to be found in the lists of analyses.

Having examined the most marked varieties met with in Arran, it may be well to add a description of a porphyritic pitchstone from the well-known Scuir of Eigg. The glassy base of this rock is of a velvet-black colour, rather dull lustre, and thickly studded with crystals of sanidine. Under a one-inch objective, a very thin section exhibits a compact grey base full of fine dust, in which there are imbedded crystals and irregular fragments of sanidine, augite, and grains of magnetite. Examined with $\frac{1}{8}$in. objective=520 diameters, the base is seen to consist of an immense number of extremely minute brown prisms, and about an equal number of granules; many of these are transverse sections of the prisms, others are black and are probably magnetite. These microlites are so crowded in the glassy base as to render it only partially translucent in the thinnest sections; they may, however, be very well seen along the sides of the felspar and quartz crystals, and in those portions of the base which extend for some distance into the crystals. They are also remarkably well shown in places where the section happens to cut the face of a crystal very obliquely, leaving a wedge-shaped layer of the base extending across it. The average size of the larger microlites is $\frac{1}{6000} \times \frac{1}{13000}$ of an inch, but the majority of them are much smaller. The sanidine is clear and transparent, and often contains portions of the base, etc. There are also a few crystals of augite and grains of magnetite included in the base. Here and there cavities of an oval form have been filled with a yellow substance, or the centre is yellow with a clear transparent border. These are evidently secondary products, and probably fill spaces previously occupied by some easily decomposed mineral.

There still remain some interesting rocks connected with the pitchstones, but a description of them must be left for another occasion.

With respect to the age of the Arran pitchstones, all that can be said at present with certainty is, that they are more recent than the Granite or the Carboniferous sandstones; they are, however, so intimately associated with the basalts and some of the quartz-porphyries —occasionally forming portions of the same dykes—that they are probably of the same age, and may owe their origin to the great Miocene volcanos which seamed the north-western coast with dykes, and poured their huge streams of basaltic lavas over a wide range of country, extending from the North of Ireland through the inner Hebrides to the Faroe Islands and Iceland.

Since the foregoing observations were written, I have had the pleasure of reading "Geological Sketches of the West-coast of Scotland," by Professor Zirkel.[1] Drawn by the hand of a master, these sketches exhibit a more accurate description of the rocks of that interesting district than can be found elsewhere, and are therefore of special interest and importance to English geologists. The paper contains a description of the pitchstones of Arran, and at first sight it occurred to me that my own account of them had thus been rendered unnecessary. There are, however, so many varieties of these rocks, so many points of interest connected with their struc-

[1] Zeits. d. d. geol. Ges. vol. xxiii. 1871.

ture, and the formation of their mineral constituents, that the facts discussed in the two papers are by no means the same; and I trust it will be found that the preceding observations have not been superseded. There is one point of some interest to which it will be necessary to advert.

At page 43 the author calls the green pyroxenic crystals *hornblende*, but gives no reason for the statement. In my paper they are described as *augite*, for the reason assigned, viz., that none of the crystals, large or small, exhibit the faintest trace of dichroism. Now, Tschermak has shown that hornblende is dichroic, while augite is not; and that we have thus, at last, a satisfactory method of distinguishing these minerals from each other. I also made the same observation, quite independently, towards the end of 1870, and have since repeatedly verified it, not only in diorites and syenites, but also in hornblende schists; in all cases this mineral is distinctly dichroic. On the other hand, all the augite examined either remains quite unchanged or, at most, exhibits a very slight variation in *shade*. It is true that some specimens of hornblende are more strongly dichroic than others, and I have observed that the pale green varieties possess this property in a less degree than those of a brown colour; still, the palest green crystals exhibit in the dichroscope a far greater difference between the two rays than I have seen in any specimen of augite. Unless, therefore, it can be shown that some hornblende is not in the least dichroic, the mineral in question must, on this ground alone, be regarded as augite. Having very great deference for the opinion of Prof. Zirkel, I have availed myself of a delay in the publication of the paper to make a re-examination of all my sections, and have found one well-formed crystal which happens to lie in such a position as to exhibit a transverse section of the prism. A careful measurement of the angles with the goniometer gives the following results: 132°; 137°; 87°; the true angles being 133° 30′; 136° 30′; 87°. Now we have here as close an agreement as can be expected under the conditions; and as the corresponding angles in hornblende are so widely different, there can be no doubt, I think, that the pyroxenic constituent of the Arran pitchstone is augite.

EXPLANATION OF PLATE I.

Fig. 1.—Section of pitchstone from the East coast, containing fern-like groups of green belonites and part of a spherolite. Described on p. 2.

Fig. 2.—Striped pitchstone from a dyke south of Tormore. See p. 6.

Fig. 3.—Pitchstone from a vein in the cliffs near Tormore, showing stellate groups of crystals in a brown glassy base. The latter should have been represented as in Fig. 1, *i.e.*, without a sharp outline round the stars. See p. 6.

Fig. 4.—Group of felspar crystals, as seen in polarized light; *a* is a twin crystal of orthoclase, showing two colours sharply divided by the plane of junction; *b*, a triclinic crystal with coloured bands. Several fern-like groups of belonites are attached to the sides of the felspar. *Magnified* 20 *diameters*.

Fig. 5.—Felspar crystals in polarized light × 20 diameters. The lower group consists of several imperfect triclinic crystals, with an angular space between them filled with the granular matrix in which they are imbedded. The dark part extending from top to bottom is of one uniform colour, and is evidently orthoclase. The upper crystal is probably an imperfect twin of orthoclase, although one half appears to con-

sist partly of plagioclase. It is known that some crystals are formed of alternating laminæ of triclinic and monoclinic felspar.

Fig. 6.—Crystal of triclinic felspar, in the porphyritic pitchstone, from Goatfell × 5 diameters. The interior is full of cavities containing brown glass. See p. 7.

Fig. 7.—The same in polarized light.

Figs. 8, 9, 10.—Imperfect quartz crystals, containing glass cavities and deep indentations filled with the glassy base. See p. 4.

Fig. 11.—Minute glass cavity of characteristic crystalline form, magnified 180 diameters. It contains a gas cavity and also a portion of the base. See p. 4.

Fig. 12.—One side of an imperfect quartz crystal, showing mode of formation of the glass cavities (p. 4). In the original drawing the sides of the neck are rather closer, and the lines curved instead of straight.

Fig. 13.—Group of crystals, surrounded by streams of belonites. Section of a porphyritic pitchstone from a dyke near King's Cove. See p. 5.

II.—On Cirques and Taluses.

By the Rev. O. Fisher, M.A., F.G.S.

I HAVE had the pleasure of reading Mr. Bonney's paper, "On a Cirque at Skye," and send you these few lines rather as an appendage to it than in the spirit of criticism. I think Mr. Bonney has made out the greater part of his case very well; but being a rather more "ardent glacialist" than he (though far less acquainted with glaciers), I do not think he has attributed quite enough to their operation in the formation of a cirque. Speaking of a Glacial period, he says,[1] "The cliffs would still be cut back, by water in summer, by frost in winter; the talus borne away or crushed by the glacier, the rocks below somewhat worn and rounded, but still the completeness of the Cirque as a whole forbids us—unless we assign it entirely to glacial action—to suppose that it was more than slightly altered by this."

I think that the work cursorily attributed to the glacier in this summary is of the essence of the question, and that without the glacier the cirque would not have been formed. I reason thus: If a homogeneous rock is subjected to simple weathering, the result is, that the surface scales off to an equal depth all over during every successive season. For instance, the vertical face of a deserted chalk pit continues vertical in the upper part until the whole face becomes masked by a talus which grows upwards from the base. I have shown in a former number of this Magazine[2] that behind this talus a parabolic contour must be formed. But what is enough for the present purpose is, that above the talus the face continues *vertical*. If then by any means the talus should be removed as fast as it is produced, the vertical form will be perpetually maintained, and carried farther back into the hill every year. The same, no doubt, will happen with any rock which is homogeneous, and sufficiently firm to stand in a vertical face If it be affected by vertical joints, its destruction will be more rapid.

Now I conceive that this is what has happened in these cirques, and that the glaciers which formerly occupied them have been the carriers which removed the talus. Their former action as such is

[1] Geol. Mag., Vol. VIII., p. 539. [2] Geol. Mag., Vol. III., p. 354.

now testified to by the moraines described by Mr. Bonney as being left within their areas. The question, whether the existence of a glacier within the area was or was not necessary to the removal of the talus, may be almost decided by observing whether the talus is or is not at present accumulating. For my own part I have a difficulty in conceiving the removal of talus from an area of such a form by streams. And Mr. Bonney when telling of the accumulating talus, says, "In not a few corries and cirques the transporting power (of streams) can hardly keep pace with the excavatory." "Hardly" is a word of doubtful signification. I have an idea that "not" would express the fact better, for he has just told us how in this one "the ice-worn slopes below are strewn with débris, and" how "their junction with the cliff is almost everywhere masked by screes." If the talus grows, the inevitable result must be that the vertical face will become in time a slope. The slope once completed, the excavation of the true cirque-wall must cease.

Thus I conclude that a cirque, though not excavated by a glacier, is strictly a glacial phenomenon.

The mountain tarns, so common in cirque-like hollows, are easily accounted for on the above principles. The tarn occupies the former bed of the glacier, and the dam, which holds back the water, is in the position held by the terminal moraine at the time when the glacier finally disappeared. I can see no other possible explanation of this common feature in mountain scenery.

But when we come to seek an explanation of the shape of the cirque, the case is not so clear. If they were always in places where many streams from above converge, this might, as Mr. Bonney suggests, cause a more rapid destruction of the rock at that locality; chiefly, however, I should suspect, by atmospheric action on the wet surface. A quaquaversal dip would also be favourable to the production of a cirque; the reason being, because the maximum resistance to destruction is not attained until the exposed face is perpendicular to the plane in which the dip lies, or, in other words, is parallel to the strike. The exposed lines of bedding would in that case appear horizontal.

In a homogeneous rock a hollow once formed would become enlarged by disintegration in all directions equally, so that a vertical chasm would in time become a cirque. Such may be the principle on which cirques in Syenitic rocks may have been formed.

There is much significance in general about a talus. One of the most remarkable features in mountain scenery is the range of talus which usually borders the valleys, and which is so often clothed with forest. These taluses are unmistakably the last formed feature of the landscape. They belong pre-eminently to the present period of geological change. Previously to their formation the valleys must have had precipitous sides, constantly dropping stones and earth, which must somehow have been continuously carried away. What carried them away? The answer must be, either sea or glacier. Few, I suppose, will refuse to give the preference to the glacier. Geologists may differ as to the extent to which these great glaciers deepened their beds. But in those beds they (or the sea) must have been, otherwise the cliffs could not have been formed.

Moreover, it is not very long ago, geologically speaking, since they were there; or else by this time the talus would have reached the top of the cliff.

On this point Mr. Geikie's paper [1] comes very opportunely. There can be little doubt but that the glaciers which occupied and barrowed away the débris of the cirques and of other cliff-bordered valleys belonged to his *third* period, viz., of moraines and raised beaches; although the excavation may have gone on at intervals, when there was just ice enough and not too much, all through the Glacial epoch, with its many changes.

I am glad to see Mr. Geikie's article headed, "First Paper." I hope in the second paper he will correlate, as far as he is able, the glacial phenomena of Scotland with those of England, and especially tell us what was going on here while Scotland lay beneath its ice-sheet. I shall be pleased if he can so far support my views [2] as to allow us a corner of it.

III.—On the Geology of Donegal.

By David Forbes, F.R.S., etc.

A DISCUSSION on the geological features of a locality between one who has never been on the spot and another who has seen so little of it as not even to know which is the bottom or top of an elaborate section which he has designed to illustrate these very features, is not likely to prove particularly instructive to the geological public, and for these reasons I would gladly have avoided it, had not Mr. Green thought proper to bring my name prominently forward in a paper entitled "Notes on the Geology of part of Co. Donegal," in last month's Geological Magazine; which paper, it may be remarked, was read and discussed on the 20th June last at the meeting of the Geological Society, although the Society subsequently declined to print it in the Quarterly Journal.

Mr. Green, not content with this decision, and resolved that the world shall not lose the benefit of his valuable labours in a, to him, evidently quite new field of geological inquiry, has reproduced it in its present form, adding a lengthy criticism on some remarks which fell from me during the discussion at the Society, thereby calling on me for a reply, which I imagine he would not have found necessary had he been present at the discussion itself.

I would, therefore, at once state that I spoke against Mr. Green's paper on principle; for the reason that whilst it did not contain a single new fact, observation, or reliable section, it showed, as he now admits, an utter want of inquiry into whether anything had previously been published on the subject, and also because I understood that the amount of time he devoted to field investigation was altogether so insignificant, in comparison to the importance of the

[1] Geol. Mag., Vol. VIII., p. 545.

[2] Geol. Journ., vol. xxii., p. 553; and Geol. Mag., Vol. III., p. 483.

subject, as not to entitle theoretical views on the origin of such rocks to any consideration unless they were supported by mineralogical, chemical, or other evidence, of which no trace was to be found in the paper.

I at the same time took occasion to deprecate a system which I fear has of late become too common: that of rushing off by steam on some hurried trip, often embracing only a few hours' actual work in the field, in order to come back with a paper for some scientific society, crude and undigested, and altogether different from the admirable memoirs to be found in the earlier volumes issued by our Society, when men like Sedgwick, Prestwich, Scrope, our lamented Murchison, and others, devoted, not hours or days, but whole weeks, months, or even years, before appearing in print, and this even when the subject may have been of a far easier nature than one which involves perhaps the most intricate of geological problems, the origin of metamorphic and crystalline rocks.

Passing now to Mr. Green's criticisms: he represents me, in the first place, as laying great stress on authorities; the very last thing to be expected from me after what I have already written on that subject; quite the reverse. I quoted Mr. Scott and Prof. Haughton for their observed facts, not for their theoretical opinions; and a mere reference to their British Association Report on this district (1863, pp. 51, 52, and 53) will prove that they describe the granite as intruding itself into and sending out veins, or dykes crossing, for example, the limestones at Drumnaha and Dunlevy; hornblendic and quartz rocks at Pollnacally and in Arranmore Island; and inclosing fragments of other rocks at Bunbeg, Loch Anure, Annagary, Toberkeen, Lough Errig, etc., etc.; the limestone beds being greatly altered at the junction with the granite, exactly as is found to be the case with igneous rocks in general. These facts I know the majority of geologists, at least, will agree with me in considering as ample proofs of the eruptive nature (in contradistinction to the sedimentary character) of the granite in question.

Mr. Green, however, although he informs us he kept his "eyes open," could not observe any instance of its "cutting across the bedding, a thing which was sure to occur somewhere if it were really an intrusive rock"; a statement which is quite easily accounted for if it is remembered how very little of the ground he actually went over in his short visit. His ideas of the nature of foliation (p. 557) would also appear to be somewhat confused, and when he (p. 560) proceeds to state "that a metamorphic rock may be at places intrusive has been explained so often that I am almost ashamed to repeat it," I would still ask him for references to any such explanation which has been accepted by geologists, or to any instances where rocks, originally of undoubted sedimentary origin, have been observed to break through or send out veins or intrusive masses into the neighbouring strata. My excuse for asking this little condescension on his part being, that having myself published various memoirs (some of which date back more than seventeen years ago), and having been hard at work in the field and laboratory, engaged in the study of these rocks for the last twenty years, I am not ashamed to ask for information which I have not been able to find in reliable works on Geology or Petrology, although I have taken great pains to make myself acquainted with the foreign, as well as English, literature of this subject; and I may further state that a personal acquaintance with many of the most distinguished foreign authors enables me to assure Mr. Green that they will join me in hoping that his modesty will not prevent his bringing forward explanatory proofs of views so extremely novel in character.

Secondly, if Mr. Green does not start with the idea, that the fact of rocks being conformable to other what he calls "undoubtedly bedded" rocks (by which I understand sedimentary strata), is a proof of their being themselves sedimentary; why does he lay such stress on these points, (p. 556, and elsewhere,) or why does he require the elaborate section he has brought forward, and which I understood Mr. Scott, in the course of the discussion, not only disputed the correctness of, but even the possibility of its ever having been gone over; and further to state, with respect to Mr. Green's co-relating the parallelism, of what I maintain are only planes of foliation, with those of true stratification, that the nearest point where "undoubtedly bedded," *i.e.*, fossiliferous rocks occurred, was separated by no less than the entire breadth of the county of Tyrone, and most probably had not been visited by Mr. Green.

As one hard fact is worth a bushel of hypotheses, I would also explain that the specimen of volcanic rock, which I laid on the table at the meeting of the Geological Society when the paper here referred to was read, was neither lava nor slag, but, on the contrary, was as thoroughly crystalline in character as the Donegal rocks; the parallel structure or *foliation* in it, being developed by the arrangement of the crystalline components themselves "in parallel layers of various thickness and different mineral composition, grain, and colour," to use Mr. Green's own words, notwithstanding that he employs them (p. 557) as "proofs of its originally bedded nature." Furthermore, it may be added that this rock extends over a vastly greater distance than the section given by Mr. Green; and that although this gentleman's knowledge of volcanic and other rocks may be so profound as to authorize him stating, "I cannot imagine there is any danger of confounding bedded structure on a large scale with the lamination of such specimens," it may be interesting to him to learn, that outlying positions of this very rock have been mapped by two eminent French geologists, MM. D'Orbigny and Pissis, as beds of sandstones, an error which can only be attributed to their having gone over the country in a very hurried manner, like Mr. Green.

After the want of appreciation experienced by Mr. Green's paper, it would be rather severe to criticize the jocose style of his concluding remarks; but as his information about my habits is evidently only on a par with what he knew of the previous literature of his subject, I would, for his better information, state, that the only talismans I believe in are: hard facts acquired in the field, application of the collateral sciences, and a knowledge of what others have done on the subject; but that I do not believe in any talisman which will enable men unacquainted with mineralogy or chemistry to reason correctly on such subjects as that under consideration, or which can metamorphose or transmute one rock into another, in defiance of all chemical or physical laws. If geologists will bring forward strange hypotheses, it is at least their duty to explain clearly by what forces these are brought about, and not attempt to conceal their own ignorance by referring everything to *metamorphic action*, whatever they may mean by such an expression.

IV.—The Age of Floating Ice in North Wales.[1]

By D. Mackintosh, F.G.S.

Sea-coast Fringe of mixed Local and Northern Drift.

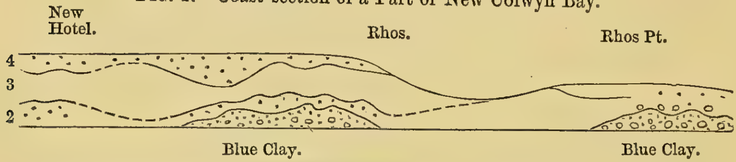
WITHOUT occupying valuable space with introductory remarks, I would begin with a description and attempted explanation of the drifts along the coast of Rhos Bay, or what is now generally called Colwyn Bay. Well-sinkings, clay and gravel pits, and coast sections, very clearly reveal a quadripartite arrangement of drifts similar to what may be seen in Cumberland. A recent well-boring at Old Colwyn went through loose gravel 9 feet; brown clay, 33 feet; and was stopped in blue clay. In Mr. Pender's brickfield, west of the Station, the pit-section and a well-boring have revealed red brick clay nearly 20 feet; sand and a little fine gravel, 16 feet; boring drill stuck fast under 60 feet of blue clay. In the ballast-pit close to the Railway Station, 30 or 40 feet of sand and gravel lie under a thin covering of red clay, the former (according to Mr. Darbishire, though this I overlooked) being underlaid by brown clay; and the sand rises up from beneath the red clay[2] at a spot south of the road between New Colwyn and Mr. Pender's brickfield. At the New Colwyn Bay Hotel, on the coast, a chip and splinter drift overlies or graduates into the red brick clay, which is underlain by sand and gravel, while the latter rests on a yellowish brown clay (here much obscured by artificial talus), from beneath which the blue clay crops out in the bed of the sea. Between the new hotel and Rhos village the cliff section shows the upper or brick clay resting on sand, be-

[1] Mr. De Rance must have read my articles on the North of England drifts very carelessly, or partly forgotten what he read, when he replied to me in his last article (Geol. Mag. Sept. 1871), for the reader will easily perceive that I have not said, or intended to be understood, what Mr. De Rance there attributes to me concerning the depth of water in which the blue clay of W. Yorkshire was principally accumulated—the per-centage of the larger boulders in Peel Park, Salford—the conditions existing during the Glacial period, etc. He has strangely, though I believe unintentionally, misstated what I said on the latter subject in the Geol. Mag. for July, 1871. References to some of Mr. De Rance's arguments will be found incorporated with the present article.

[2] The sand or middle drift everywhere, but especially in the neighbourhood of hills, shows a tendency to raise its head suddenly above the Upper Boulder-clay, so as to appear on the same or even on a newer horizon.

neath which the yellowish brown clay, underlain by the blue, rises up from under the sea. At one point there is a very curious dovetailing of the blue into the brown clay. Some distance seaward from Rhos village, the blue clay makes its appearance at low water. Beyond Rhos village, the yellowish brown clay becomes very conspicuous, and resembles a local subdivision of the Lower Boulder-clay which may be traced along the sea-coast of Cumberland, Lancashire, and Cheshire. It is lost under sand, again shows its face, and further on, beyond Rhos Point, overlies undulating bosses of the blue clay, which there appears in full force.

Fig. 1.—Coast-section of a Part of New Colwyn Bay.



2. Lower brown clay. 3. Sand and gravel. 4. Upper red or brick clay.

Peculiarities of the Blue and Brick Clays.—The dark blue, bluish-grey, or sometimes bluish-green clay, is pack-full of small stones, and, in its lower part, larger stones mixed with enormous boulders. It may have been principally derived from the grinding down of the dark Silurian shale or slate which may be found in the neighbourhood. The smaller stones are generally flat oblong fragments of dark shale or slate. Their form must have interfered with their becoming rounded by rolling, but where stones of a different nature are found in the same clay they are often well rounded. They are generally scratched on both sides in nearly every direction, but

Fig. 2.—Both sides of a striated stone from the Colwyn Blue Clay.

seldom distinctly grooved. They look as if they had been "bandied about" while entangled in coast-ice, which finally left them imbedded in the clay. The large boulders[1] reach an average diameter of seven or eight feet near Rhos Point, and consist chiefly of limestone, a gritty rock with veins of calcareous spar, a greenish rock graduating into porphyry greenstone apparently of the Welsh type, Silurian hard shale or slate, volcanic breccia, etc. They may nearly all have come from the neighbourhood; but as I dug out of the blue clay two pebbles of Eskdale granite, and found one of Criffell granite on

[1] They seldom exhibit marks of much flattening through grinding, though some of those which consist of limestone are so irregularly scratched all round, that a gentleman from Chester, who disbelieved in a Glacial period, contended that a party of boys had been disfiguring the boulders in play.

the beach close by, it is clear that, while this clay was in course of being accumulated, an ice-laden current from the far north must have mingled with the local currents of the Glacial sea.[1] The brick clay, or uppermost drift, is usually of a reddish colour. It contains very few large boulders, but a considerable number of small rounded stones, which consist of Lake District porphyry, Eskdale and Criffell granite, Silurian light-coloured grit or sandstone, local limestone, shale, etc., etc. The stones in the brick clay are generally more flattened on one side, deeply and uniformly grooved, and more polished than in the blue clay, so that if any member of the Colwyn drifts is to be exclusively elevated to the rank of a Glacial clay, this brick clay, and not the blue, ought to have the preference; and yet the submarine accumulation of this clay is, I believe, admitted by all geologists.[2]

Between Conway and Bangor.—The Boulder-clay west of Conway seems to be on the horizon of the lower brown member of the northern drift. About Penmaenmawr, sand and gravel may here and there be seen overlying this clay which, near the entrance of the tunnel, attains a thickness of at least 60 feet. It clings to the base of the steep slope of Penmaenmawr hill, is often a real pinel, and contains northern erratics mixed with blocks which must have fallen into it from above when the ice-laden sea beat furiously against the flanks of the Snowdonian mountains. The Boulder-clay thins out upwards under a talus of recent screes which thins out downwards. Between the west end of the tunnel and Llanfairfechan there is an unusually crowded Boulder-scar, which contains stones from the north, including both Eskdale and Criffell granite. At some distance from the sea, above Llanfairfechan church, a brook has revealed a good section of a knoll, consisting (at least partly) of pinel which is a facsimile of what I once saw near Baycliff, Morecambe Bay. One of the numerous included boulders reclined on a thin bed of laminated loam, exactly in the same manner as I had seen near Baycliff. A great thickness of gravel and sand, apparently resting on Boulder-clay, is exposed in the cutting at the east entrance of the tunnel through Bangor hill. At the entrance to the next tunnel on the west side of Bangor valley, the Lower Boulder-clay (of which only patches remain) has been dovetailed into sand and gravel. Here and there on both sides of the valley, above the level of the sand and gravel, this clay, often partaking of the character of pinel, may be seen filling up recesses. Traces of a blue clay may likewise here and there be discovered. The obliquely laminated and contorted sand and gravel near the Station (and which is only a part of an extensive terraced deposit, running southwards

[1] I fear that Miss Eyton, who has made some important contributions to Post-tertiary geology, has been misinformed about the existence of blue clay around Crewe. I could see or hear nothing of it, though I found that some persons gave the name blue clay to the upper red brick clay with greyish-tinged fractures, which there overlies the middle sand and gravel.

[2] It is not, however, the only shell-bearing clay, for shells have been found in the lower brown clay at Llandudno by Mr. Darbishire, and by others in the same clay in Lancashire and Cheshire.

for a considerable distance),[1] reminded me very much of the section I had seen near Lorton, Cumberland. In a pit to the north of the Station, the sand is convoluted similarly to what may be seen near the Coniston Copper Works. Near Upper Bangor I found a small boulder of Eskdale granite which had come out of clay in the neighbourhood; and I afterwards met with two boulders of the same kind of granite on the ridge about a mile south of Bangor New Church.

Around Beaumaris.—North of Beaumaris the sea has encroached on a gradually-swelling knoll, and exposed a section, about 40 feet thick, of upper red clay with scarcely any boulders, but a considerable number of small stones, and a few sand seams. It rests on a brown Boulder-clay (precisely resembling what may be seen on the coast near Workington), which is much harder, and contains many more stones, the lower part being full of large boulders consisting principally of limestone from the adjoining area to the north. Among the stones in general may be found porphyry, felstone, quartz, Cambrian conglomerate, foliated Cambrian rocks, different kinds of granite, etc. Specimens of Eskdale granite may be seen lying on the beach, and I picked two out of the lower or brown clay. Many of the boulders are much glaciated, and those of them which exhibit a flattened side with parallel grooves are generally cross-striated in addition, while the majority of the stones are striated in various directions and often all round. The occurrence of northern drift stones (besides granite, many of the felstones and porphyries, are probably from Cumberland) in this clay, viewed in connexion with their presence along the coast of Caernarvonshire, and their distribution in a S.S.W. direction to a great distance, clearly points to a branch of the great northern drift current which thickly strewed the plains of Lancashire, Cheshire, and Shropshire with Scotch and Cumberland erratics. This current may possibly have split on the N. end of the Snowdonian range of mountains, so as to direct the main course of the floating ice to the S.E.,[2] and a small part of it to the S.S.W.; so that Professor Ramsay, many years ago, was right in believing that Anglesey was once subjected to the action of icebergs from about the N.N.E. point of the compass.

Roches Moutonnées formed by Floating Ice.—On the elevated ground about half a mile S.W. of Bangor New Church, I found striæ pointing N.N.E. On the other side of the Menai Strait, less than a mile from the tubular bridge, the eminence on which the Monument stands, presents a fine example of a *roche moutonnée* rounded and smoothed on all sides except the S.W., which is precipitous and jagged. Though no striæ are visible, the parallel undulations point to about the N.E. as the direction from which the iceberg or icebergs came—

[1] A great part of the Anglesey side of the Menai Strait is covered with stratified sand and gravel. A fine section may be seen in a large pit about half way between Menai Bridge and the Monument.

[2] I have seen no granite on the northern slopes of the Snowdonian hills, or in the Vale of Conway about Trefriw and Llanrwst, but further eastwards it would appear to have been floated some distance into the interior of the country. I have a bit of Eskdale granite which Dr. Williams, of Wrexham, found in a heap of mixed bone and stone débris which had been dug out of Cefn Cave, near St. Asaph.

their sources being probably the higher valleys of the Lake District at a time when the N.W. of England and Wales was deeply submerged. The greater part of the drifts, as may be inferred from the height above the present sea of the sources of their stony contents, must have been accumulated under water too shallow to float large icebergs. Coast-ice, by freezing round and uprooting stones, débris, clay and sand, and likewise by receiving loads of detritus from cliffs and slopes, must be capable of removing much more drift-matter than those icebergs which are the broken-off ends of high level glaciers; but while icebergs alone could have been sufficiently powerful to uniformly grind down and mammilate large rocky projections, the comparative paucity of foreign drift (it is not altogether absent) around these mammilated rocks in Anglesey may thus be easily explained. There is no difficulty in accounting for the preservation of the mammilated form during the rise of the land through the upper part of the tidal range, for these rock-surfaces may have remained covered with drift until just before their final emergence, or they may never have been covered, and yet they may have risen above the sea with their general form uneffaced, for we know that at the present day glaciated rocks stretching from above to beneath the sea on the coasts of Ireland, Scotland, and Norway, have resisted the action of the waves for years; and I am familiar with what some years ago was a highly polished limestone surface on the W. coast of Morecambe Bay, and which, notwithstanding its subjection to the action of waves wielding pebbles, is still so smooth that care is necessary in attempting to walk over it, while some of the striæ can still be dimly discovered. A short distance E. of the Monument there is a well-preserved *roche moutonnée*, which has been glaciated up-hill from about the N.E. The large shallow grooves may still be detected under favourable light and shade, and the much larger parallel undulations are very well defined (see Fig. 3).

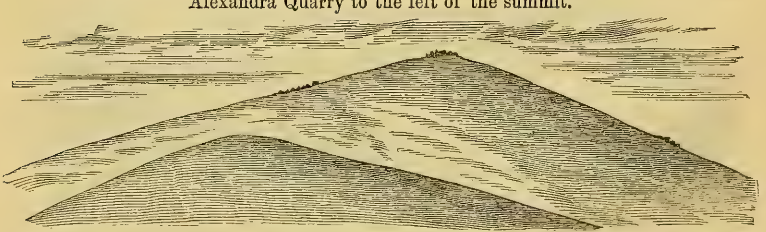
Fig. 3.—*Roche moutonnée* in Anglesey, looking leeward or down-stream.

Northern Drift on Moel-y-Tryfan.—On the celebrated Moel-y-Tryfan, five miles S.E. of Caernarvon,[1] mixed local and northern drift may be found. In the 35 feet of irregularly-stratified gravel and sand which rises from the floor of the highest excavation of the Alexandra slate quarry to within a few yards of the rock-crested summit of the hill, there are some large felspathic and porphyritic

[1] Not the stupendous break-neck wedge of felstone, called Y Tryfan, at the head of Nant Francon, from going to which, in search of sea-shells, I lately prevented an eminent *savant*.

boulders (chiefly at the bottom of the section), and many pebbles in the gravel, which may have been worked up from their parent rocks on the N.W. side of the hill by waves and coast-ice as the land was sinking; but a large percentage of the pebbles certainly, and some of the large boulders probably, were derived from the far N. The stones in general are subangular, and consist of felstone deeply weathered white, from the N.W. side of the hill; porphyry partly from the N.W. side of the hill, and partly, I believe, from Cumberland; local slate; several kinds of granite from Cumberland and Scotland; felspathic breccia and ashes from a greater or less distance; quartz and a rock resembling gneiss from the N.W. side of the hill (?); etc., etc. Among the granites there are many pebbles and some good-sized stones of very decided Eskdale and Criffell granite. The latter (which must have travelled no less a distance than 130 miles!) is generally of the same kind as the principal variety found in the drifts of Cumberland, Lancashire, and Cheshire, and is a perfect facsimile of granite now quarried by the Messrs. Newall at Craig Nair, near Dalbeattie.[1] The Eskdale granite embraces several varieties with which I was familiar on the E., W., and N. sides of Eskdale, and between the latter and Wastwater foot; it is likewise of the same kinds as those found in the Lancashire and Cheshire drifts. These granites must have been carried to near the top of Moel-y-Tryfan by rafts of coast-ice when the land was too deeply submerged to permit any granite falling on the surface of glaciers terminating in icebergs. Indeed, there is some difficulty in seeing how even coast-ice could have picked up granite from the Eskdale fells at a height of nearly 1400 feet above the present sea-level. The difficulty might be obviated by taking into consideration the progressively-upward action of sea-waves and coast-ice on Moel-y-Tryfan, were it not that I failed to see any granite pebbles on the hill-slopes at a lower level, though such may possibly exist.[2]

Fig. 4.—Distant View of Moel-y-Tryfan, from near Bangor. Alexandra Quarry to the left of the summit.



The N.W. side of Moel-y-Tryfan is covered with drift varying from loamy sand to hard pinel, being often a mass of subangular or

[1] The Shapfell and Dalbeattie Company are quarrying granite near Dalbeattie of a somewhat different kind with a tendency to run into groups of oblong crystals of felspar of a more or less brownish hue.

[2] Mr. Trimmer, in his Geology (1841), mentions the existence of granitic detritus at eight points between the Menai Strait and Snowdon, but he only specifies Moel-y-Tryfan, and says nothing, so far as I can remember, about the character of the granite.

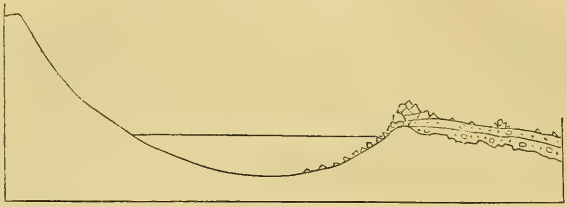
angular stones, mainly felspathic. On the way to Caernarvon there are thousands of large boulders, chiefly porphyry and felstone. Between Caernarvon and Bangor the lower brown Boulder-clay, in places passing into pinel, may be seen in the railway cuttings, and a little blue clay under the brown may be detected near Port Dinorwic.

From Bangor to Marchlyn-mawr.—Between these two places the drift is chiefly the lower brown Boulder-clay, with an occasional greyish tinge towards the surface. It varies from a loose stony and gravelly clay to hard pinel, its general character, however, being nearly the same as that of the lower brown clay of the coasts of Anglesey, Cumberland, Lancashire, and Cheshire. It is generally full of stones and boulders, consisting of directly or indirectly local porphyry, grit, etc. The boulders, though often much rounded at the lower levels, are, in most places, seldom well glaciated. In the valley near Pentir, and elsewhere, this clay is overlain by mounds and plateaux of stratified sand and gravel (excepting where the latter rest on rock), which were probably in part washed out of the clay during the rise of the land,[1] for though a great thickness of sediment can of course only be amassed on a subsiding sea-bottom, yet such comparatively thin, and often sandbank-like, deposits as those under notice would be more likely to be accumulated during emergence. Away from the coasts of N.W. Wales I have nowhere seen sand and gravel regularly and persistently interpolated between a lower and upper Boulder-clay, but in the area under consideration an upper red or foxy-coloured loam or clay may often be seen resting on the brown Boulder-clay. This may be observed at the Turbary W. of the Penrhyn slate quarries, where the lower clay attains a great thickness. From the Turbary the two drifts slope smoothly upwards to the small lake called Marchlyn-mawr, 2000 feet above the sea-level. As Professor Ramsay has suggested, the lake-basin was probably ground out by a glacier; for—though at first it may seem unlikely that a glacier which, on ascending, smooths a projecting boss of rock, leaving its lee-side jagged, should excavate a rock-basin at the bottom of a previously-existing cwm—it must be taken into consideration that in a cwm a short glacier would press "downwards and outwards," that the constant melting of its fore part by the sea would leave the entrance to the cwm comparatively or entirely beyond the reach of the grinding ice, and that the entrance in consequence would remain as a barrier to the lake. The basin of Marchlyn-mawr (like several other lake-basins in North Wales) appears to me as if it had been formed while the land was sinking, and as if it had been partly filled with marine drift, and occupied (after the rise of the land) by a second small glacier, which ploughed out the greater part of the drift and left the striking moraine of angular loose blocks which rests on and conceals the inner termination of the marine drift immediately in front of the

[1] According to Professor Ramsay, the shell-bearing sand and gravel of North Wales was arranged while emerging, or during terrestrial oscillations of level (*Old Glaciers of North Wales*, p. 95).

lake. On the outer side the moraine rises about 20 feet above the drift plateau. On the inner side the top of the moraine is perhaps 40 feet above the level of the lake.[1]

Fig. 5.—Section of Marchlyn-mawr.



From Bethesda to the highest Marine Drifts.—About Bethesda, and in Nant Francon, decided pinel may occasionally be seen; but the visible drift (probably underlain by pinel or brown clay, especially at the lower levels) in the areas traversed by the Llafar, Caseg, and Berthan, varies from a clayey loam, or rather loose foxy-coloured loam, more or less charged with stones and boulders, to a rubbly or gravelly loam, often so pack-full of stones as to assume their colour when viewed from a distance. The stones are angular, subangular, and occasionally rounded. They are either directly or indirectly local, though many of them must have been floated to their present positions irrespectively of the drainage of the country. Comparatively few of the stones are distinctly glaciated. The drift and its stony contents presents the appearance of a heterogeneous accumulation, resulting from the action of sea-waves washing down stones and finer detritus from hill-slopes unfavourable to the exercise of littoral attrition, to lower levels, combined with the dispersive action of stone-freighted coast- or pack-ice. To these agencies we must add the distribution by the sea and floating ice of precipitated moraine débris. Indeed, in many places, as Professor Ramsay has shown, the drift is chiefly spread out moraine-matter, and might be called morainic marine drift. The existence of the drift on slopes, ridges, and watersheds, proves that it could not have been spread out by rains or small mountain streams; while the fact of its stretching up with smooth and flat outline to the higher ends of valleys shows that its distribution could not have resulted from mere sub-aërial glacial action. Moreover, the discovery of sea-shells in what must be regarded as a downward extension of this drift by Mr. Trimmer, and in similar drift near the Turbary by the late Mr. Griffith Ellis, completes the evidence in favour of its accumulation under the sea.

[1] Professor Ramsay believes that this and a number of other lake-basins in North Wales were formed by glaciers which terminated in the sea as the land was rising, that they kept the marine drift out of the basins until they rose above the sea-level, and that the glaciers finally melting the basins were occupied by fresh water. But it may be asked, Did the cwms at the bottoms of which the lake-basins were excavated contain glaciers before the sea (through the movement of the land) had risen up to their levels? or were they only occupied by glaciers after the sea had retreated down to their levels?

In the Cwm Llafar and adjacent areas, this drift may be traced upwards, as Professor Ramsay has shown, to 2300 feet above the sea, and I believe to a greater height. In Cwm Llafar there are terraces "the result of marine denudation during pauses in the re-elevation of the country" (Ramsay). These terraces, so far as I could see, are similar to thousands of platforms and scarps which diversify hill-slopes in various parts of England. They are not so regular, horizontal, or continuous, as those terraces which can be traced to an artificial origin. With great interest, as might be expected, I gazed on the long narrow channel, evidently ploughed out by a glacier in the drift, as Professor Ramsay has shown. In some places it is as fresh-looking as if it had been excavated within the memory of man. Here, as in hundreds of other spots in Wales and the Lake District, we have clear proofs that since the Glacial period even rapid and good-sized *freshwater streams have not lowered the level of the valleys they traverse more than a few feet.*

Professor Ramsay, in his "Old Glaciers of North Wales," p. 101, has drawn attention to a very important fact. Freshwater streams cannot remove (and it follows that they cannot deposit) drift consisting of a mixture of huge boulders with finer detritus. They wash away the finer and lighter matter and leave a concentration of boulders behind. But, it may be remarked, if freshwater could not have accomplished the clearance of boulder drift so strikingly indicated by the long narrow hollow in Cwm Llafar, how could it have transported the blocks, the abstraction of which has left the magnificent mural cliff at the head of the cwm. Freshwater is now assisting frost and gravitation in demolishing this cliff, but it is clearly unable to carry away the talus of fallen fragments.

P.S.—Since the above was written, I have discovered a number of very large boulders, chiefly Eskdale granite, at a height of very nearly 1000 feet above the sea, on Raw Head, one of the Peckforton Hills, which rise suddenly out of the plain of Cheshire. I have also found calcareous incrustations on a stone from the Colwyn Upper Clay, and on numerous stones from the Upper Clay of Cheshire. They look like the remains of *Serpulæ*. [Specimens sent by Mr. Mackintosh to the Editor for inspection were certainly not of organic origin, but calcareous incrustations only, deposited by water charged with carbonate of lime.—Edit. Geol. Mag.]

V.—On Changes of Climate during the Glacial Epoch.

By James Geikie, F.R.S.E.,
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Second Paper.

In the Magazine for December[1] I gave a brief outline of certain phenomena connected with the Scottish Till, the chief aim of my paper being to insist that beds of clay, sand, and gravel frequently occur in that deposit, and that we can no longer consider these as either insignificant or accidental. I also showed that while some of

[1] pp. 545–553.

the beds referred to are of marine origin, many have been deposited in fresh water. I believe my brother was the first to recognize the significance of these beds, although the fact of their occurrence in the Till was previously well known. He showed that the accumulation of the Till must sometimes have been interrupted and certain valleys cleared of ice "up to a height of at least 800 or 900 feet above the present level of the sea." Since the publication of his paper on the Scottish Drift,[1] inter-Glacial beds have been met with in almost every part of the country; and from the fact that they occur not only in the Till of the Lowlands but also in that of the deep and narrow valleys of the Southern Uplands, we are warranted in concluding that the warmth of the inter-Glacial periods was sometimes such as to melt off the ice entirely from the Lowlands; for at a time when streams were flowing in the deep green valleys of the Peeblesshire hills, it is utterly impossible that glacier ice could have rested upon any portion of the great Central Valley. If glaciers continued to exist in Scotland throughout each inter-Glacial period, they could only have done so in the retired glens of the Highlands and some of the high valleys among the mountains of Galloway.

The disappearance of a *mer de glace*, which in the Lowlands of Scotland was probably over 2000 feet in thickness, could only have been effected by a very considerable change of climate. Nor does it seem at all unreasonable to suppose that the comparatively mild and genial periods, of which some of the inter-Glacial beds are memorials, may actually have endured for as long a time as those arctic or glacial conditions which preceded and followed them.

We shall probably never learn how many great changes of climate took place during the accumulation of the Till and its associated deposits. This arises from the fact, already adverted to, that during every period of intensest cold, when the country was covered with a more or less thick sheet of snow and ice, the loose materials which in the preceding age had gathered in river valleys and in lakes would almost inevitably be subjected to excessive denudation. That the records of mild inter-Glacial periods should be at the best but fragmentary is no more than one might have expected. The wonder is not that they should be so interrupted, but that any portion whatever has been spared. And yet in sheltered hollows we find sometimes two, sometimes three, and even four beds of Till separated by intervening deposits of gravel, sand, and silt. We cannot assume, however, that only four cold periods and three intervening ages of milder conditions were comprised within the first stage of the great Glacial epoch. For aught that we know there may have been many revolutions of climate. But however that may have been, no one who shall give the matter some thought will doubt that the lapse of time represented by the Scottish Till and its intercalated beds must have greatly exceeded that required for the deposition of the subsequent marine and later glacial drifts. We have a difficulty in conceiving of the length of time implied in the gradual increase of that cold

[1] Trans. Glasgow Geol. Soc. vol. i. part ii.

which eventually buried the whole country underneath a mass of ice some 2000 feet in thickness. Nor can we have any proper conception of how long a time was needed to bring about that other change of climate under the influence of which slowly and imperceptibly this immense sheet of frost melted away from the Lowlands and retired to the mountain recesses. We must allow that long ages elapsed before the warmth became such as to induce plants and animals to clothe and people the land. How vast a time, also, must have passed away ere the warmth reached its climax, and the temperature again began to cool down. How slowly, step by step, the ice must have crept out from the mountain fastnesses, chilling the air, and forcing fauna and flora to retire before it; and what a long succession of years must have come and gone before the ice-sheet once more wrapped up the hills, obliterated the valleys, and, streaming out from the shore, usurped the bed of the shallow seas that flowed around our island. Finally, when we consider that such a succession of changes happened not once only but again and again, we cannot fail to have some faint appreciation of the lapse of time required for the accumulation of the Till and the inter-Glacial deposits.

The deposition of the Till was succeeded by a movement of depression, during which the overlying series of gravel, sand, and brick-clays was thrown down. These beds have been so often described, and their general appearance is so well known, that any account of them here would be quite unnecessary. It need only be remarked that the sand and gravel beds appear for the most part to be derived from the wreck of the Till and also from that of the terminal moraines that marked the gradual retreat of the ice-sheet. But of this more anon. The marine drifts invariably recline either upon a sorely eroded surface of Till or upon bare rock. In places where the Kame-series is wanting the Till has usually a much less eroded appearance.

I have elsewhere[1] pointed out the remarkable distribution of the Kames in Scotland, and shown that none of these peculiar mounds occur in valleys which at the period of greatest submergence would become deep quiet fiords. In such places the Till forms broad flat terraces, whose slope coincides with the general inclination of the valleys. But this deposit has either vanished or appears only in meagre patches in valleys which, during the period of submergence, must have existed as sounds or straits connecting opener spaces of sea. It is precisely in such valleys, however, where we meet with the most typical assemblages of Kames. I have inferred from these facts that the last-mentioned valleys were swept by currents which denuded the Till, and heaped up banks of sand and gravel; while in the quiet "fiord valleys" no currents moved, and consequently the Till was left undisturbed, and no Kames were formed.

An occasional boulder found in the heart of a Kame shows that during the accumulation of the Kames ice must have been floating about. But I have often remarked that while such included boulders are of somewhat rare occurrence, numbers of erratics, some of con-

[1] Trans. Glasgow Geol. Soc. vol. iii. part i. p. 54.

siderable size, are not infrequently found perched upon the tops or scattered over the slopes of the Kames. By far the greater number of Kames which I have examined contain no erratics whatever, and those which do show an occasional boulder may be of later date than the others. My colleagues' experience is similar to my own; and as we have now mapped and examined by far the largest areas of Kames that exist in Scotland, it may, perhaps, be assumed, with some degree of certainty, that the occurrence of "included" boulders is the exception. From this and certain other appearances, it seems reasonable to infer that the accumulation of the Kame-series *began*, at all events, at a time when but little ice, if any, was floating about in the sea. But the quantities of erratics that cumber the surface of the Kames both in Scotland and other northern countries appear to show that after a large proportion of the Kames and cones of sand and gravel had been heaped up, bergs and rafts of ice dotted the surface of the sea and strewed their burdens of angular débris and boulders over the sea-bottom.

It has sometimes been argued that the disappearance of the ice-sheet, underneath which the Till accumulated, was caused by the coming in of the sea, consequent upon a subsidence of the land. But if this had been the case, the Kame-series must have been formed at a time when floating-ice was plentifully present: and the gravel ridges ought therefore to be as well stocked inside as outside with a supply of erratics. From the fact that they are not so, I would infer that previous to the commencement of the period of submergence the land-ice had already vanished from the low grounds, and that, consequently, during the early stages of subsidence, and even down to a time when the sea had increased to a considerable depth over the land, no glaciers reached the coast-line.

We have no certain record of what transpired in the interval that elapsed between the deposition of the last patch of Till and the heaping-up of the earliest mounds of sand and gravel. The gradual retirement of the last ice-sheet must have cumbered first the sea-bottom, and then by-and-by the land, with great heaps of angular blocks and rubbish. Long before the ice had entirely vacated the bed of the shallow seas around our coast, it must have so diminished in thickness as to have ceased to be confluent over a large part of Scotland. As the cold decreased, mountain tops and rocky ridges would begin to stand boldly up above the level of the *mer de glace* and separate it by slow degrees into a series of local glaciers. One by one these would "faint and fail," the little ones of course being the first to die out. But by-and-by even the larger glaciers would melt back from the sea and creep up their valleys. The result of this recession of the glaciers would be to cover both the sea-bottom and the land with stones and rubbish, or moraine matter. And seeing that the Kames seldom or never contain angular erratic blocks (although these occur commonly enough perched upon their slopes), it seems legitimate to infer that the ice had in large measure melted away from the land before submergence ensued, and, consequently, that there is no necessary connexion between the disappearance of the ice and the incoming of the sea.

When the land began to sink down, the terminal moraines left behind by the retreating glaciers would be tampered with, and their materials, well winnowed and water-worn, would be re-arranged, so that little or no trace of anything like moraines would be preserved. Here and there, however, we find thick masses of coarse, unstratified moraine-like matter, wrapped round by heaps of marine sand and gravel in such a way as to show that the latter must belong to a later date than the former. The occurrence of these odd masses of coarse moraine débris, surrounded on all sides by deposits of fine gravel and beautifully false-bedded sand, used to be a great puzzle to me. The difficulty was got over at first by supposing them to be "iceberg droppings," but when several years had bettered my acquaintance with the marine drifts, and I found that boulders almost never appeared inside the Kames, I began to think that my explanation of the moraine-like rubbish was only an "explaining away." By-and-by, however, what appears to be the true solution of the problem dawned upon me. I am now persuaded that this coarse, unstratified débris with angular blocks represents the relics of the huge terminal moraines which the old glaciers must have left behind them on their retreat to the mountains. From the exact resemblance of this rubbish to that of the Swiss moraines, there is no reason for believing it to have been formed in any other way than these have been. The probabilities are strong that the moraine-stuff to which I refer accumulated upon a land-surface, and not upon a sea-bottom.

After the subsidence had carried down the land to some considerable depth, and many or most of the Kames of sand and gravel had been heaped up, the glaciers would once more appear to have entered the sea, and bergs and coast-ice to have formed and carried away with them heaps of angular rubbish and débris. It is a nice question whether this entry of the glaciers was caused by an increase of cold, or whether it might not have been induced by the subsidence itself, which gradually brought the glaciers within reach of the waves. Either hypothesis will harmonize with the facts. All we know for certain is that at a late time, when the submergence had already reached some extent, and currents had piled up a vast series of sand and gravel ridges, glaciers reached the sea and shed plentiful crops of bergs. To this date must be referred the solitary erratics which are scattered far and wide over hill and dale in the Lowlands; and also those great heaps of partially water-arranged moraine-stuff which sprinkle so large an area in the undulating ground about the base of the Galloway Mountains in the south of Scotland and the Grampians in the north. Local glaciers probably existed in the Peeblesshire hills at this time, but none of them appear to have reached to the level of the sea.

Erelong the re-elevation of the land began. Step by step the country rose out of the waves, the various pauses in the upward movement being marked by a great succession of terraces and shelves at all heights from over 1000 feet downwards. The Kames and mounds appear in some places to have been planed off and their materials re-assorted. Yet a vast number escaped this levelling process to puzzle future geologists as to "how they managed it." To the period of re-elevation I feel inclined to refer all the post-Glacial clays with Arctic and Boreal shells. I do not, however, mean to say that any hard and fast line can be drawn between these deposits and the Kames; nor would I think of denying the possibility of shell-bearing clays having been deposited during subsidence. Both kinds of drift may have accumulated on different parts of the same sea-bottom, but the only junction of the two I ever had the luck to detect showed plainly that the clays abutted against the sand and gravel, and even spread over the truncated or flattened tops of the Kames. I never found Kames resting upon any of the Arctic shell-beds. Not that I think these facts taken by themselves go for much. It might be said that as the land sank down, the clays would naturally come to lie upon the gravels, the deep-sea deposits overlapping the shallow-water accumulations. Yet if they did do so, it is certainly singular that they have never been detected in the interior of the country. Irregular patches of laminated clay occur here and there in hollows of the Till at considerable heights above the sea, but it is often doubtful whether they are of marine or freshwater origin. None of them, at all events, have yielded arctic shells. If arctic shelly clays ever occurred in as thick beds in the inland as in the maritime districts, surely we should have found some notable trace of them. It will not do to lay the blame of their disappearance on that geological scapegoat *denudation*. Denudation has not run off with the Kames, why should it have been less considerate with the clays? The Kames have come down to us almost, if not quite, in the same state as the sea-god left them; but if shelly clays ever existed in the interior parts of the country, they would appear to have vanished, and left not a wrack behind. If it was in Scotland only where the arctic shell-clays were confined to the maritime districts, there might be some excuse for dragging in denudation to account for their absence at the higher levels reached by the Kame drift; but in Norway and Labrador and Maine the shelly clays are restricted precisely as in Scotland to the vicinity of the sea-coast. In North America, sand and gravel drift goes up to great heights, but the shelly clays reach no higher than 500 or 600 feet above the sea; and, what is still more to the purpose, they show a gradual passage upwards from beds containing a prevalence of Arctic forms to beds in which the organic remains are the same as those in the neighbouring seas. I believe our arctic shell-beds will yet be found to do the same.

In attempting to account for the absence of arctic shell-clays at the higher levels attained by the marine drift, we must bear in mind that the Kames and shelly clays have been formed under very different conditions. The former evidently consist of the re-arranged material derived from the waste of pre-existing glacial deposits, and, as far as that goes, might have been accumulated in the waters of a warm ocean; the latter are composed of fine mud washed out directly from the snouts of glaciers. During the accumulation of the

Kames it is doubtful whether there were any glaciers entering the sea; if this was so, the supply of glacial mud would be stopped, and the absence of glacial clays from the interior parts of the country may thus be accounted for. It is true that much mud would result from the denudation of the Till; but we may be quite sure that the currents which heaped up the gravel ridges would not permit the fine mud to settle down save at great distances from the land. The deposition of the shelly clays took place at a time when glacial mud was being poured into every quiet fiord on our coast; but this was during the period of re-elevation. From these and other considerations, which want of space forbids me to enter upon, I think it is most probable that the shelly clays belong as a whole to a later date than the Kames, and were deposited under colder conditions of climate than the last-mentioned accumulations. At the time some of the shell-beds were forming glaciers reached the sea in many of our firths, and icebergs and coast-ice floated about.

The re-elevation of the land continued, and erelong glaciers ceased to reach the sea. An amelioration of climate had again ensued. Slowly the glaciers crept up the valleys, leaving behind them a number of moraines, some of which are finely preserved.

The later stages of the history are well known. Scotland probably became connected with the continent across the upraised bed of the North Sea. By this time the climate had greatly ameliorated, and the country, along with a large part of Northern Europe, became covered with dense forests.

The subsequent depression of the land and the insulation of Britain must have tended still further to temper the cold of winter, although at the same time the warmth of the summers would also be somewhat reduced. The decay of the ancient forests probably dates its beginning from this period. The more recent raised beaches indicate still later changes in the relative level of land and sea, but a consideration of these is beyond the purpose of this paper.

Since the time that the shelly clays were deposited down to the present we have no trace in the post-Glacial beds or recent alluvia of any warm climate having intervened. From the close of the Glacial period the climate has regularly and successively become milder: neither post-Glacial nor recent alluvial deposits give the slightest hint that any considerable oscillations of temperature have taken place since then.

To sum up, then, the results at which we have arrived, I shall in a few words recapitulate the points which I have endeavoured to bring prominently forward.

1st. The Till[1] of Scotland with its intercalated beds indicates a vast lapse of time, during which there were several great revolutions of climate, how many we do not know.

[1] I think it much to be desired that the terms *Till* and *Boulder-clay* should not be applied to one and the same deposit. If *Till* were taken to mean simply the material collected underneath land-ice, the moraine profonde of Swiss geologists, it would save confusion. *Boulder-clay* could then be applied to those more or less stratified clays with boulders which have been deposited in water. In my previous paper I have used the two terms interchangeably; in the present paper, however, and in future, I will apply them in the manner just suggested.

2nd. The beds of Till point to intense arctic conditions having prevailed at the time of their formation.

3rd. The deposits of silt, clay, sand, and gravel, with land-plants and mammalian remains, and in some places with marine shells, all of which beds are intercalated in the Till, clearly show that the intense arctic cold which covered the country with an ice-sheet was interrupted, not once but several times, by long continuous ages of milder conditions. Some of these periods may have been warmer than others, just as some of the glacial periods may have been colder than others.

4th. So far as direct evidence goes, we cannot say that any one of those inter-Glacial periods was characterized by a warmer climate than is now enjoyed in the forest regions of high latitudes in America.

5th. Considering the sorely denuded appearance of the inter-Glacial deposits, and keeping in mind the nature of the conditions under which they have been preserved, it would be rash to conclude that they contain a complete record of the changes which ensued during inter-Glacial times, or that we are entitled to argue from the few fossils yielded by them that the climates of the inter-Glacial periods were never positively warm.

6th. A mild or temperate period followed upon the final disappearance of the great ice-sheets. There is no reason to suppose that this change of climate was caused by the sinking down of the land and the incoming of the sea. The probabilities are that the glaciers had retired a long way from the sea before subsidence commenced, and had left the ground covered here and there with heaps of loose terminal moraine rubbish.

7th. During the process of subsidence that ensued the Kame-series of sand and gravel was formed. Little or no floating-ice existed in our seas at this time.

8th. When the subsidence had become considerable the glaciers again entered the sea, and bergs and coast-ice scattered stones and blocks across the sea-bottom. These blocks and stones strew the tops and slopes of the Kames and occur in the shelly clays.

9th. The clays with arctic shells belong to the period of re-elevation.

10th. The subsequent changes indicate a gradual amelioration of climate down to the present.

Such are the general results which appear to be fairly deducible from what is known of the Scottish Drift. It is so easy to correlate the various Glacial deposits in Scotland, and to read off the succession of events, that it becomes interesting to inquire to what extent the sequence obtained in other northern regions harmonizes with the conclusions stated above. For if it be found that not only in Northern Europe and North America, but in Switzerland also, the order of succession of the drift deposits tallies precisely, this will doubtless serve as a guide towards unravelling the more complicated drifts of the low grounds of England. My limits, however, will not allow me to do more than bring together into as short a space as I can the main results arrived at by foreign geologists. I have found a wonderful unanimity in these results—geologists working apart and in widely-separated countries coming as near as may be to the same conclusions.

(*To be continued in our February number.*)

NOTICES OF MEMOIRS.

I.—Memoire sur le Cœlacanthus Harlemensis, par Dr. T. C. Winkler. Haarlem, 1871. 8vo.

THIS is one of several memoirs by Dr. Winkler, descriptive of new, rare, or of more perfect examples of previously-described vertebrate fossils, preserved in the Teyler collection at Haarlem, and which originally appeared in the third volume of its Archives. It is an addition to the literature of the small but interesting group of fossil fishes which constitute the family of Cœlacanthini, as established by Prof. Huxley in his "Preliminary Essay on the Systematic Arrangement of the Fishes of the Devonian Epoch,"[1] the genera and species being more fully described and illustrated in a subsequent Memoir.[2]

Since the publication of this essay, Professors Wagner, von Alberti, Kner, and Quenstedt, have each written and added to our knowledge of the subject. And, more recently, M. Willemoes-Suhm has published an excellent memoir on the species of *Cœlacanthus* in the 17th volume of the "Palæontographica," 1869. The group is an exceedingly interesting one to the palæ-ichthyologist, both as regards its peculiar anatomical structure and its long persistence in geological time; its range extending from the Upper Carboniferous beds to the Chalk inclusive. And during this long lapse of time it has (so far as our knowledge extends) only been represented by about 20 species.

The typical genus of the family—*Cœlacanthus* of Agassiz—first appears in the Coal-measures, and is found in the Permian and Triassic formations, and also in the Upper Oolite or Lithographic stone of Bavaria. *Holophagus* of Egerton occurs in the Lower Lias at Lyme Regis, and is known only by a single species.[3]

Macropoma, Agass., is represented by three species, one in the Kimmeridge clay, and two in the Cretaceous deposits; and, according to Sir Philip Egerton, an undescribed species occurs in the Purbeck beds near Swanage. Thus, of the twenty recorded species, sixteen are referred to *Cœlacanthus* and *Undina;* but this last name has been set aside, as a synonym of the first, by later writers, which our author greatly regrets, seeing that Count Münster was the first to observe and describe the principal characters of the peculiar organization of these Fishes, and that his genus *Undina* had the priority of Agassiz's *Cœlacanthus*.

[1] Memoirs of the Geological Survey. Decade X.

[2] Illustrations of the Structure of the Crossopterygian Ganoids. Memoirs of the Geological Survey. Decade XII. 1866.

[3] Memoirs of the Geological Survey. Decade XII. Pl. 6.

The specimen on which Dr. Winkler founds his new species is from the Lithographic stone of Eichstadt. It is in a good state of preservation, its length being thirteen inches ; the head is somewhat mutilated, but the orbital, opercular, and maxillary bones, are easily recognized, but, unfortunately, there is no trace of the teeth. A slender line which extends from the neck to nearly the end of the tail, marks the position of the spinal marrow (moëlle épinière), or dorsal chord, forming a ribbon divided into small squares, and which is protected above and below by bifurcated bones, which terminate in single points,—the neural and hæmal arches. The fins are entire and in their natural positions. A large portion of the integumentary envelope is preserved, which our author thinks is naked or devoid of scales, but covered with numerous small spots or groups of very fine striæ, and these groups have between them spaces which are not striated. On examining these striæ with a magnifying glass, he finds that they are composed of long tubercles, a little undulated, and sometimes bifurcated, and they are covered by a fine coat of enamel. Upon comparing his specimen with the figures and descriptions of the other most perfect example known, the *Cœlacanthus striolaris*, Münster, our author finds that both specimens are alike in size and general form, and in the relative size of the head to the body ; in the number and position of the fins, and in having a principal, and an accessory caudal fin placed at the end of the dorsal chord ; and also in the dorsal and anal fins being each supported by a broad flat bone, and not upon interapophysary osselets. He says they differ in the following particulars :—

1. *C. striolaris*, according to M. Willemoes-Suhm, has 19 rays in the second dorsal fin, his has but 13 or 14.

2. The anal and second dorsal fins have each 19 rays in *C. pencillatus;* in his specimen there are but 10 or 11 rays.

3. A difference of a few rays is also observed in the first dorsal.

4. The difference in the number of the rays of the pectoral fin is also great between the two species,—13 or 14 in *C. pencillatus*, 20 in his.

5. The ventral fin in *C. striolaris* is small; in his specimen it is the largest of all the fins.

6. *C. Kohleri* shows plainly fulcra to the first dorsal and the caudal, but none of the fins of his specimen have these small spines on the edges of the rays.

7. The specimens in the Munich Museum have scales, and also fulcra, which are but modified scales, and the absence of fulcra in his specimen coincides with his view that the skin was naked or covered with small dermal tubercles.

These differences, he thinks, are quite sufficient to prove that his *Cœlacanth* is a new species, and which Dr. Winkler names *Cœlacanthus Harlemensis*, for the very novel reason that it was first studied and described in the town of Haarlem.

The memoir is illustrated with a fine tinted plate.—W.D.

II.—Memoirs of the Geological Survey of India. Vol. VII. Art. VII. The Káranpúrá Coal-fields. By Theo. W. H. Hughes, F.G.S., Assoc. Roy. School of Mines, Geological Survey of India.

In this Memoir Mr. Theodore Hughes, of the Indian Geological Survey, brings before us the history of the mineral wealth of the Damúdá valley, in connexion with its coal and iron-bearing deposits, which was commenced by the issue of the Report on the Ráníganj field, and systematically continued in those of the Jherríá, the Bokáro, and the Rámgarh fields.

The total area of all the Damúdá Coal-basins is about 2000 square miles, estimated as follows:—

1. Ráníganj	1000 square miles.	4. Jherríá	200 square miles.
2. Káranpúrá	472 „	5. South Káranpúrá	72 „
3. Bokáro	220 „	6. Rámgarh	40 „

The size of the Ráníganj field is stated approximately. Its known area is 600 square miles, but there is every reason to suppose that it extends for many miles eastward beyond its furthest known or mapped point in that direction. The areas of the other Coal-basins are accurately given, as they differ from the Ráníganj field in having their boundaries definitely terminated by the appearance of the crystalline series, which, in the Damúdá valley, forms the floor upon which the Coal-measures and their associated rocks rest.

Although the Ráníganj field is by far the most important of the Damúdá Coal-basins, owing to its superior size compared with the others, and its geographical position as regards Calcutta, the Káranpúrá Coal-fields will also be of considerable value as areas of supply to the towns of Hazáribagh, Ránchí, and Gya; and for economic purposes in connexion with the Sone irrigation works, which have lately been initiated by the Government of India.

The area of the Káranpúrá fields is 544 square miles, and they have been roughly estimated to contain 8835 million tons of available coal.

Associated with this coal there are valuable deposits of iron-ore, which have within the last few years attracted much attention; and some preliminary surveys have been commenced with a view to setting up ironworks, and connecting them by means of a branch line with the main system of the East Indian Railway Company.

The size and importance of the Coal-fields of our great dependency are little known, and it may be of interest and high importance to learn that in extent the coal-area of India stands third in the list of countries, and that in thickness its seams are unsurpassed by any in the world.

Mr. Hughes' memoir concludes with some important general considerations regarding the physical conditions under which the coal-rocks were deposited, and the organic contents of the period. He argues that the entire series of formations developed in the Damúdá Valley Coal-fields is of land and freshwater origin, and adduces as proof: evidences of water (current) action resembling those which may be seen in the recent valley deposits of Indian rivers; and the absence of marine organic remains highly favours the views of Mr. Hughes—this being borne out by the great preponderance of fossil plants over other organic remains in the Damúdá and Panchít plant-bearing formations.

It would appear that the coal-bearing rocks of the Káranpúrá Coal-fields, and consequently the Coal-flora of this part of India, belong to the Trias, or even later; and such plants as *Glossopteris, Tœniopteris*, and *Priessleria*—also occurring in Queensland in rocks which are unquestionably of Secondary age—may through closer investigation be found to be of nearly the same epoch. Associated with the flora are Labyrinthodont and Dicynodont remains, the latter significant of the Poikilitic group in India, Africa, and Europe.

The Economic Summary shows the local value and importance of this Coal-field and the industrial wealth associated with this important fuel.

Estimates as to quantity are assuring for the future of India. Analyses of iron-ores associated with the coal are given and bear comparison with our British deposits.

The surveys of our colonies are looked upon in a different light by the general population when immediate utility is impatiently looked for, or when material gain almost entirely sways the public and official mind. Under these circumstances the usefulness of such a memoir as this by one of the officers of the Indian Survey in keeping alive the interest in the proceedings of our Colonial Geological Surveys cannot be over-estimated.

REVIEWS.

L.—The Earth: a Descriptive History of the Phenomena of the Life of the Globe. By Elisée Reclus. Translated by the late B. B. Woodward, M.A., and Edited by Henry Woodward, British Museum. Continents:—Sections I. and II. Two vols. 8vo., pp. 666.[1] (Chapman and Hall, 1871.)

JUST as our stage is indebted to French writers for the plot and groundwork of the numerous "adaptations" which form the bulk of the *répertoire* of our actors of light comedy, so are our popular scientific gift-books mostly translations of French compilations, such as the one whose title stands at the head of this article. But there is this difference. While French comedies require for an English audience so much "adaptation" of their ornament and incident that they cease to be sparkling, the compilations of French *savants* can be allowed to retain their brilliancy. The latter possess a sufficiently polished surface, and leave nothing to be desired but a more solid background to reflect their light and irradiate their readers; but the former require the aid of a moral Nemesis to neutralize the artificial attractiveness of their vice. In a word, French science is too poetical, just as French comedy is too prurient.

The book before us well represents a French scientific compilation of the first rank; and its possession of the idealism characteristic of its nationality serves chiefly to invest its theme with a "harmony" and even with a "rhythm" which are not the less attractive because they are inconsequent. Thus, although "the Earth" has been the subject of many books by many writers, from Hutton's "Theory" to Gosse's "Omphalos," and from Strabo amongst the ancients to the Goldsmith of our schooldays, we do not remember any book which has covered exactly the same ground as M. Reclus's "La Terre."

[1] The two remaining volumes are now in the press.—Edit.

Commencing with a description of the Earth as a planet, the author gives a brief but accurate sketch of its astronomical relations, importing into his description from time to time his views on its past, present, and future condition. He believes that great catastrophes have already occurred, and that a succession of cataclysms will take place before the "vitality" of our globe becomes annihilated. Its rate of rotation is already diminishing in a perceptible degree, and M. Reclus sees in this and some other phenomena sufficient proof that, after a series of internal convulsions, the earth's history will terminate with the fall of our planet upon the surface of the sun as a series of meteorites.

These preliminary chapters will acquire more significance in the mind of the reader after he has mastered a portion of the next division of the work, entitled "The Land." He will then find that the occasional paragraphs about "vitalities," "harmonies," and "rhythms," which at first will strike him, probably, as being mere poetical forms of expression, are really indicative of the ruling idea of the author in his contemplation of telluric phenomena. He will continually find accurate statements of facts unaccompanied by any reference to their cause, but illustrated by comparisons with analogous phenomena which the author regards as either harmonious or rhythmical.

In his description of "The Land," M. Reclus confines himself to the present epoch, and treats his subject as a portion of Physical Geography. This science he rightly regards as descriptive of the earth as it exists before our eyes, and as preparing the way for Geology by collecting and classifying facts which we can now verify, and by their aid discovering the laws of the formation and destruction of strata. Taking this line of argument, and importing into it the idealism to which we have already drawn attention, M. Reclus makes the second portion of his work an elaboration of the truth of the following statement (p. 40):—

"The globe of our earth is in evident conformity to all the laws of harmony, both in the spherical uniformity of its shape, and also in its constant and regular course through space. It would, therefore, be incomprehensible if, on a planet so rhythmical in all its methods, the distribution of continents and seas had been accomplished, as it were, at random. It is true enough that the outlines of coasts and mountain ridges do not constitute a system of geometrical regularity; but this very variety is a proof of a higher vitality, and bears witness to the multiplicity of motions which have co-operated in the adornment of the earth's surface."

As an illustration of his ruling idea, we give a short synopsis of his mode of correlating certain terrestrial phenomena as harmonious, merely premising that we select one or two sets as typical of his method, and that the same process is applied to the comparison of all the phenomena which have been made known to us by the researches of travellers and physical geographers.

The dry land of the earth is classified by our author as three double continents, forming three parallel series. Of these double continents, North and South America form one pair; Europe and Africa another, and Asia and Australia the third. The duality of North and South America is evident to every child who understands "the use of the globes;" but when a comparison is attempted between this and any other pair, the author is constrained to draw more or less on his imagination. He owns that Europe might be looked upon as a mere geographical appendix of Asia; but he disposes of this objection by the fact that "at some previous epoch it [Europe] was separated from Asia by a sheet of water, which stretched from the Mediterranean to the Gulf of Obi, through the present Euxine, Caspian, and Aral Seas." He does not stop to inquire what was the condition of the African continent at that period; whether the Sahara was submerged, and whether the whole face of the sub-aërial land was not so altered in contour that it presented no analogy with the continents of the present day. Again, confining ourselves to the land-surface of the world as it exists to-day, is not the division between the continents of Europe and Asia purely arbitrary? It is not political, because portions of both the Russian and Turkish Empires extend into Asia. It is not philological; for, if it were, the peninsula of Hindostan would be joined to the remainder of the region inhabited by the nations which speak languages belonging to the Indo-European family. And it is neither ethnological nor theological, for similar reasons to those that it is not political.

The author finds little difficulty in pointing out a series of similitudes between South America and Africa; but in comparing them with Australia, he is compelled to exercise his idealism to even a greater extent than in his comparison of Europe and Asia with America, and especially in his attempt to construct an isthmus comparable with that of Suez or Panama. This essential feature he finds represented in the Sunda Islands, which he justly enough regards as "the piles of a demolished bridge."

M. Reclus does not, however, consider his similitudes to be mere fancies. He regards them as the evidences of the action of two sets of forces which have for ages been exerted at right angles to one another. He points to a series of circles of geographical phenomena, such as the "circle of fire," which extends from the chain of the Andes across the southern ocean; to "the circumpolar circle of coasts" around the North Pole; to the "circle of inland seas and lakes" represented by the Mediterranean, the Euxine, the Caspian, the Siberian and American lakes, and the Bay of Fundy; also to the "semicircle of deserts," which is arranged obliquely across the continents of Asia and Africa. All these, with the directions of the axes of the northern continents, show, in his opinion, that they are the result of a set of forces acting obliquely to the Equator.

The other set of forces he considers to have produced the distribution of the southern continents in three lines parallel to the meridian. "To this complication," he observes, "is due the apparent irregularity of the double continents in the Old World; for there the two axes of formation cross, and consequently there, too, is produced a great diversity in the relief of the land. The mutual resemblances and contrasts exhibited by the two halves of the world can, however, be pefectly well explained if we connect them with one or the other of these two orders of facts. If we look upon the land as forming three parallel double continents, we must then be struck with the similarity which they mutually present both as a whole and in details; if, on the contrary, we admit the usual division of the continental masses into two worlds, we discern the reason of the contrasts, which are only another kind of resemblance. . . . . Just as in a woven fabric, we can discern both the warp and the woof in the marvellous texture of the earth's surface."

It is fortunate for M. Reclus that his ideas of harmony and rhythm are so plastic; for in his next attempt—which is the last to which we shall draw attention—their elasticity is put to even a more severe test. After drawing attention to the similarity in the shape of the terminal points of the three southern continents, and to the existence of an island, or a set of islands, on the southern side of each, he proceeds to show that these three continental promontories are represented by three peninsulas in each of the three northern continents—another evidence of harmony and rhythm of the highest order. Thus, commencing with Europe and Asia, Spain corresponds with Arabia; Italy with Hindostan (even to the existence of an island near the southern extremity of each), and Greece with India beyond the Ganges. "With regard to Greece and the Transgangetic peninsula, the seas which bathe their eastern coasts are dotted over with innumerable islands and islets, like a brood of young birds nestling under the wing of their mother. The two other eastern peninsulas, which are also thrown off by the great Asiatic continent, are each of them likewise accompanied by an archipelago." But the European representative of these last is not mentioned.

The author's ideas of harmony, however, suffer the greatest wrench during his comparison of the two trios of northern Old-World peninsulas with their North American representatives. Can our readers trace the harmonious analogy between California, Spain and Arabia, between the Isthmus of Panama, Italy and Hindostan, or between Florida, Greece, and Transgangetic India? M. Reclus manages to sustain his theory in this last effort; but, to our mind, his success speaks more of his ingenuity than of his philosophy.

Pursuing a similar method, M. Reclus discusses the relations of the Plains and Deserts, the Mountains and Valleys, and the other features of "The Land," and in subsequent chapters treats of "The Circulation of Water" and "The Subterranean Forces." The latter portion of the work is also strongly marked by idealism, like the chapters which we have selected as being most appropriate for discussion in a Geological Magazine. All his statements are interesting, all fresh, and all readable, although it must be said that they contain little or nothing true that is not "familiar in our mouths as household words."

Not even M. Reclus, however, can find "harmony" in all the phenomena of the globe. Indeed, he signally fails in the case of the ages of geological strata in the various countries of the world. "Nowhere do they present absolute harmony." His conclusion takes the form of a question, and he asks, "How much [of this want of harmony] is owing to a difference of epoch, and how much to a diversity of climate? The solution of this problem is one of the great tasks of science." (p. 31.) We are of opinion that De la Beche, Edward Forbes, and Professor Huxley have taught us in England to reduce this "want of harmony" to a principle, which we know as Homotaxis; and we believe that some way has been made in the endeavour to ascertain the value of each factor in the numberless equations which Comparative Palæontology presents to us. But would M. Reclus be "surprised to learn" that this geological variation is harmonious with an astronomical one described by himself? "The attraction of the moon and the disturbances caused by the vicinity of certain planets are incessantly modifying the curve described in the starry fields of space by the earth's axis, and complicate it with a multitude of spirals, the various periods of which do not coincide with the great period of the swaying of the axis. The successive undulations form a continuous system of interwoven spirals. 'It is a manifestation of the Infinite.'" (p. 12.) Just as the moon and the planets modify the path of our globe round the sun, so have volcanic, meteorological, and other terrestrial phenomena modified the climate, the depth of the sea, and the distribution of land and water, which have produced the "want of harmony" in geological strata in different parts of the globe. The geologist of the present day who believes in the philosophy of his science looks forward to the time when the history of all these perturbations may be as clearly read by him as the ancient path of the world can be calculated by the astronomer.

The two volumes which we have received do not complete M. Reclus's work; but we have refrained from consulting the complete French edition, as we hope on a future occasion to resume our discourse on the sequel, and to show, if possible, how the author gathers up his lines of harmony and rhythm, and connects them by means of a scientific theory with the laws which are known to have produced the varied phenomena which he has hitherto compared with each other.

The translation to which we have confined ourselves was made by the late Mr. B. B. Woodward, M.A. (Queen's Librarian), and it has been edited by his brother, Mr. Henry Woodward, F.G.S., etc., of the British Museum. The volumes are very well got up, excellently illustrated by twenty-four page-maps printed in colours, as well as by more than two hundred woodcut figures inserted in the text. As a gift-book on Popular Science, we can strongly recommend it, especially to those who expect such publications to interest their friends if opened at random and read for a spare half hour. We cannot say that it is faultless; but when the work is completed we expect to find a table of *Errata*, in which, for instance, the editor will assure his readers that the word "Crustaceæ" is a misprint, and not meant, as a double plural, to be a philological illustration of the author's theory of double continents.—H. M. Jenkins.

II.—Flints, Fancies, and Facts; a Review of Sir Charles Lyell's "Antiquity of Man," and similar Works.[1] By William Robinson, of Cambridge. London: Longmans. 8vo. 1871. pp. 28. (With a lithographic plate.)

THE author of this little pamphlet, who is doubtless "a burning and a shining light" in his own small circle at Cambridge, has been drawn to make a few observations on the *ignes fatui* of the scientific world whose false beams have obscured, though doubtless only for a season, the light shed by Mr. William Robinson. The names of these false luminaries specially selected for extinction are Boucher de Perthes, Lyell, Lubbock, Lartet, and Christy, and Mr. John Evans.

Mr. Robinson writes more in pity than in anger of these men. "Surprisingly strong," he observes, "as may be their prejudices, alien as are their principal conclusions from their premisses, the dupes, as we conceive them to be, of one fondly cherished illusion, and the not blameless propagators of dangerous errors, it is due to them to say that their writings contain proofs of their readiness to confess mistakes into which they had previously fallen, and abound with proofs of their desire to describe with honest accuracy what they have seen" (p. 1).

We regret that we are unable to attribute the same candour and honesty of purpose to the author of this pamphlet; for, wishing to throw doubt and discredit on the discovery of flint inplements of undoubted human manufacture in the drift, he has selected for figuring some of the most rude examples which he could find, and those not from the drift, but from the far more recent though still historically speaking ancient encampments, and from the surface-soil; and lest even these poor chips should speak and confound him before his hearers, he turns their faces to the wall, and so has them figured![2]

The existence of the more highly finished forms of implements from the river gravels he entirely ignores.

That the selection of these particular chips (part of a series presented by Mr. John Evans, F.R.S., F.S.A., to the Fitzwilliam Museum, in Cambridge) was designed intentionally to throw discredit upon the whole inquiry, and also upon one of our most able investigators and best authorities upon stone-implements of all ages, cannot be doubted; but, fortunately, Mr. Evans's high reputation as

[1] "This Review appeared in the 'London Quarterly Review,' in October, 1871, but without the pictorial illustration."—Note by the Author.

[2] Every one who has taken the trouble to examine a wrought flint flake will remember that on the side next the core from which the flake was struck they are smooth and slightly concave longitudinally, with a raised mark at one end indicating "the bulb of percussion," whilst on the outside they usually show a ridge, or two or more nearly parallel longitudinal ridges or lines, where other flakes, previously struck off the core, had separated from them; or they give evidence of side-chippings when the flint has been worked subsequently. The flints as figured by Mr. Robinson are but fragments of wrought flakes, but they, of course, conceal any trace of this chipping or grooving, being, as we have said, turned away from the spectator, and only exhibit their smooth inner side. Even this is so coarsely and rudely printed in the lithograph that any evidence they might have afforded in this position is lost.

an antiquary does not depend upon the verdict of Mr. William Robinson; nor are these the only flint implements of a rude and early type known in this country; and, moreover, it has never been pretended, except by that ingenious writer, that any one of them is of Palæolithic age.

The author is good enough to observe that "so far as" his "remarks are depreciatory, they are not intended to apply to *Reliquiæ Aquitanicæ*, a yet unfinished work, which is chiefly descriptive, and illustrated by fine plates, and which is published—at, we presume, considerable pecuniary loss—in memory of Mr. Christy, by his surviving friends." This would have been consolatory to M. Lartet, and no doubt is so to the Christy Trustees, and Professor T. Rupert Jones, the accomplished editor of the *Reliquiæ Aquitanicæ*.

Of M. Boucher de Perthes, who died 2nd August, 1868,[1] the author observes: "Since this article was prepared, intelligence has reached this country of the decease of M. Boucher de Perthes, a gentleman of Picardy, and author of more than forty volumes, who, rather than any other, may be styled the founder of that school which has for the prominent article of its creed, belief in "the antiquity of man." Mr. Robinson derives a page or two of fun out of M. de Perthes "Antiquités Celtiques et Antédiluviennes," pretending to imagine that because M. de Perthes collected queer-shaped flints (like our friend Major-General Twemlow, of Guildford), under the supposition they were remains of organic beings, or tokens of human ingenuity, that therefore all the rest of the objects that his museum contained were equally valueless and untrustworthy. He also, as so many other writers have done, ridicules the excitement created in April, 1863, by the discovery of the celebrated Moulin-Quignon Jaw, associated with flint-implements of the drift-type, which led to the Conference of Antiquaries and Geologists at Paris and Abbeville in May, 1863. Mr. Robinson does not state the truth as to the nature of the evidence relied upon in the case of the flint-implements from the valley of the Somme, when he says "that the theories which Lyell and Lubbock have deduced from the flint phenomena of that valley rest mainly, if not solely, on the ingenious frauds of the workmen" (p. 13). So long ago as October, 1858, Dr. Falconer visited Abbeville, and saw in M. de Perthes collection (then quite unknown to fame) *genuine* flint implements, (agreeing with those from the Brixham Cave), exhumed by Perthes himself, and associated with the molars of *Elephas primigenius* (Falconer's Palæontological Memoirs, vol. ii., p. 597).

"I arrived," says Dr. Falconer, "at the conviction that they were of contemporaneous age, although I was not prepared to go along with M. De Perthes in all his inferences regarding the symbolical hieroglyphics, and an industrial interpretation of the various other objects which he had met with" (*ibid*, p. 597).

With regard to the forgeries, Dr. Falconer justly observes, "The great demand for flint-implements arises from the number

[1] See his Obituary Notice, Geol. Mag., 1868, Vol. V., October Number, p. 487. Monsieur Boucher de Perthes was 79 years of age when he died.

of strangers who now (1863) visit Amiens and Abbeville, attracted by the general interest which the subject has of late years excited. The supply of genuine implements proved insufficient, and the natural result followed. Considering the facility with which counterfeits can be made, half a franc per *hache* would upon a considerable sale be amply remunerative, apart from the larger sum derived from specimens professing to occur *in sitû*" (*ibid*, p. 613).

A better argument in favour of the human origin of these implements than their now being successfully reproduced by human, though fraudulent, agency can hardly be conceived.

As regards the selection of such names for criticism as those of Sir Charles Lyell and Sir John Lubbock, it seems both necessary and expedient to a man of the Robinson type that he should associate his unknown name with those of men of mark and high repute; but peacocks' feathers do not conceal the jackdaw beneath; and the character of lion sits as ill on the author as it did on Snug the Joiner in Midsummer Night's Dream. Indeed, the part played by our author is very much like Snug's, "for it is nothing but roaring."

REPORTS AND PROCEEDINGS.

Geologial Society of London.—Nov. 22, 1871.—The Rev. Thomas Wiltshire, M.A., F.L.S., in the Chair. The following communications were read:—

1. "Notes on some Fossils from the Devonian Rocks of the Witzenberg Flats, Cape Colony." By Prof. T. Rupert Jones, F.G.S.

In this paper the author noticed some Devonian fossils like those of the Bokkeveld, found on Mr. Louw's farm on the Witzenberg Flats, Tulbagh. *Orthoceras vittatum*, Sandberger, was added to the South-African list of fossils. The fossils under notice were stated by the author to help to substantiate the late Dr. Rubidge's view, that the old schists termed "Silurian" by Bain are of Devonian age, and continuous across the Colony. Their presence in the Witzenberg Flats was also shown to be conclusive against the idea of Coal-measures being found there.

Discussion.—Mr. Godwin-Austen remarked that the presumed Devonian species of South Africa appeared not to have been completely identified with those of European origin. Although, judging from the range of European marine mollusca, some of which were found of precisely the same species both in Europe and at the Cape, there was nothing surprising in the extension of any old deposit, yet it seemed unreasonable to suppose that the whole district over which the wide-spread Devonian rocks extend could have been submerged at the same time. He traced the original foundation of the Devonian system to the late Mr. Lonsdale, who, in the fossils found in the deposits of Devonshire, thought he traced sufficient grounds for a marked discrimination between those beds and those of Carboniferous age. Mr. Austen had, however, always regarded the Devonian system as merely an older member of the Carboniferous, holding much the same relation to it as the Neocomian to the Cretaceous; and he would be glad to see it recognized, not as an independent system, but merely as the introduction of that far more important system the Carboniferous, during the deposit of which the globe was subject to the same physiographical conditions.

Mr. Etheridge did not agree with Mr. Austen as to the suppression of the name of Devonian system, and commented on its wide-spread distribution, and on the peculiar facies of its fossils, and their importance as a group. He was rather doubtful as to specific determinations arrived at from casts. Though the species of many fossils from Queensland procured by Mr. Daintree did not correspond with those of European areas, yet some of the corals were identical with those of South and North Devon, as were also the lithological characters of the containing beds.

Mr. Seeley objected to any attempt to supersede the arrangements of the South African rocks in accordance with the local phenomena, by correlating them too closely with any European series. The recognition of the correspondence in forms seemed to him more to prove a similarity of conditions of life than any absolute synchronism. As to the connexion between the Devonian and Carboniferous systems, he agreed with Mr. Austen in regarding the one as merely constituting the natural base of the other.

2. "On the Geology of Fernando Noronha (S. lat. 3° 50′, W. long. 32° 50′)." By Alexander Rattray, M.D. (Edin.), Surgeon R.N. Communicated by Prof. Huxley, F.R.S., V.P.G.S.

The author described the general geological structure of Fernando Noronha and the smaller islands which form a group with it. The surface-rock was described as a coarse conglomerate, composed of rounded basaltic boulders and pebbles, in a hard, dark-red, clayey matrix. This overlies a hard, dark, fine-grained basalt, which forms the most striking of the bluffs, cliffs, and outlying rocks. The highest peaks in the group consist of a fine-grained, light-grey, granite. The author remarked upon the possible relation of the geology of these islands to that of the neighbouring continent of South America, and stated that there is evidence of the islands having been elevated to some extent at a comparatively recent period.

3. "Note on some Ichthyosaurian remains from Kimmeridge Bay, Dorset." By J. W. Hulke, Esq., F.R.S., F.G.S.

The author noticed some teeth found, with a portion of an Ichthyosaurian skull, in the Kimmeridge Clay of Dorsetshire. The fragments of the snout were said to indicate that it was about three feet long, and proportionally stout. The author indicated the characters by which these teeth were distinguishable from those of various known species of *Ichthyosaurus*, and stated that they approached most closely to those of the Cretaceous *I. campylodon*.

Discussion.—Mr. Seeley did not consider that, in the main, the teeth of reptilia afforded any criteria for specific determination. In the Cambridge Greensand, though there were five species of *Ichthyosaurus*, possibly including a second genus, the teeth found were so closely similar that it would have been impossible, from them only, to identify more than one species.

Mr. Boyd Dawkins recognized in the specimens exhibited by Mr. Hulke a form of tooth he had found in the Kimmeridge beds of Shotover, near Oxford, but which he had been hitherto unable to attribute to any recognized species. He could not fully agree with Mr. Seeley as to the absence of specific criteria in the teeth of Saurians, as, from his own experience, he was inclined to attribute some importance to their external sculpturing.

4. "Appendix to a 'Note on a new and undescribed Wealden Vertebra,' read 9th February, 1870, and published in the Quarterly Journal for August in that year." By J. W. Hulke, Esq., F.R.S., F.G.S.

The author generically identified this vertebra with *Ornithopsis*, Seeley, *Streptospondylus*, Owen, and *Cetiosaurus*, Owen, taking the last to be typified by the large species in the Oxford Museum. He remarked that if this be the type of *Cetiosaurus*, *C. brevis*, Owen, can hardly belong to it, as the trunk-vertebræ are described as being of a totally different structure.

Discussion.—Mr. Boyd Dawkins, who had recently visited Oxford, stated that he had there examined the remains referred to. There was, however, no tooth found with them of a character to show the nature of the food on which the animal subsisted. But one of his students had lately found in the same pit that had afforded the remains, a tooth corresponding in its principal characters with those of *Iguanodon*, with which, therefore, the *Cetiosaurus* seemed to be allied, so that it was probably a vegetable feeder. Mr. J. Parker had lately procured from the Kimmeridge Clay a number of Saurian remains, and among them were some vertebræ of *Megalosaurus*, to which were articulated others presenting distinctly the characters of *Streptospondylus*. He thought that probably many of the supposed Streptospondylian vertebræ might prove to belong to the cervical region of Dinosaurians.

Mr. Seeley disputed the attribution to *Cetiosaurus* of the vertebræ described, and questioned whether the remains at Oxford might not be assigned to *Streptospondylus* or *Ornithopsis*. The depressions in the vertebræ, which might be connected with the extension of the air-cells of the lungs, did not exist in *Cetiosaurus*, but were to be found in *Megalosaurus*. As to the premaxillary tooth mentioned by Mr. Dawkins, he was uncertain whether it should be referred to what he considered as *Cetiosaurus* proper, or to the Oxford reptile.

Mr. Hulke replied, pointing out that, since the determination of the Oxford reptile as *Cetiosaurus*, numerous other remains of the same species has been discovered which had added materially to the basis of classification.

II.—December 6, 1871.—Joseph Prestwich, Esq., President, in the Chair. Fourteen new Fellows were elected, and Prof. Giovanni Capellini, of Bologna, was made a Foreign Correspondent of the Society.

The President announced the bequest to the Geological Society on the part of the late Sir Roderick Murchison, of the sum of £1000, to be invested in the name of the Society or of its Trustees, under the title of the "Murchison Geological Fund," and its proceeds to be annually devoted by the Council to the encouragement or assistance of geological investigations. The donation of the proceeds of the Fund was directed by the Testator to be accompanied by a bronze copy of the Murchison Medal.

The Secretary, Mr. Evans, having read the extracts from the Will of the late Sir Roderick Murchison relating to this bequest,

Sir Philip Egerton proposed the following resolution:—That this Meeting, having heard the announcement of the bequest made to the Geological Society by the late Sir Roderick Murchison, desire to record their deep sense of the loss the Society has sustained by his death, and their grateful appreciation of the liberal bequest for the advancement of Geological Knowledge placed at their disposal by their late distinguished Fellow.

Mr. J. Gwyn Jeffreys seconded this proposition, which was carried unanimously.

The following communications were read:—1. "On the presence of a raised beach on Portsdown Hill, near Portsmouth, and on the occurrence of a Flint Implement at Downton." By Joseph Prestwich, Esq., F.R.S., President.

The author noticed a section observed by him in a pit ten miles westward of Bourne Common and five miles inland in a lane on the north side of Last Cams Wood. It is situated at an elevation of

300 feet above the sea-level, and shows some laminated sands with seams of shingle, overlying coarse flint-shingle with a few whole flints, which the author regarded as a westward continuation of the old sea-beach, which has been traced from Brighton, past Chichester to Bourne Common. A flint flake was found by the author at the bottom of the superficial soil in this pit. The author also noticed the occurrence of a flint implement of the type of those of St. Acheul in gravel near Downton in Hampshire. This gravel capped a small chalk-pit, and its elevation above the river Avon was about 150 feet. Two gravel-terraces occur between this pit and the river, —one 40–60, the other 80–110 feet above the level of the latter.

Discussion.—Mr. Codrington stated that, according to the Ordnance Survey, the level of the pit at Cams Wood was not more than 100 feet above the sea, so that it was at about the same level as the gravels of Titchfield and elsewhere.

Mr. Evans remarked that the flint flake from Cams Wood presented no characters such as would prove it to be of Palæolithic age. He was, on the contrary, inclined to regard it as having been derived from the surface. He commented on the height at which the Downton implement had been discovered, which was, however, not so great but that the containing gravels might be of fluviatile origin.

Mr. Gwyn Jeffreys thought that if the beds at Cams Wood were marine, some testaceous remains might be found in them. If these were absent, he should rather be inclined to regard them as fluviatile.

Mr. J. W. Flower contended that the gravel at Downton could not be of fluviatile origin. He thought indeed that the gravel was actually at a higher level than the present source of the river. If this were so, he maintained that the transport of the gravel by fluviatile action was impossible. He further observed that gravels precisely similar, also containing implements, had now been found, as well in the Hampshire area as elsewhere, the transport of which, in his view, could not possibly be attributed to any existing rivers. At Southampton they occur 150 feet above the river Itchen and the sea, and considerably inland; at Bournemouth, on a sea-cliff 120 feet in height; and at the Foreland (at the eastern extremity of the Isle of Wight), on a cliff 82 feet above the sea, and far remote from any river. If, therefore, these deposits were effected by fluviatile agency, it was evident that all traces of the rivers were afterwards effaced by some great geological changes, or, in the alternative, some great geological change, not fluviatile, must have caused the deposit. Upon the whole he was disposed to conclude with the French geologists, as well as with many eminent English authors, that the accumulation of all these superficial drifts was, as the late Sir Roderick Murchison had said, sudden and tumultuous, not of long continuance; and thus it was such as would result from some kind of diluvial action, rather than from the ordinary long-continued action of water.

Mr. Judd pointed out, in contravention of Mr. Jeffreys's views, that in the Fen district, over large tracts of deposits of undoubtedly marine origin, not a trace of marine shells could be found.

Mr. Prestwich, while willing to concede that the implement-bearing gravel-beds had been deposited under more tumultuous action than that due to rivers of the present day, was still forced to attribute the excavation of the existing valleys and the formation of terraces along their slopes to river-action. He showed that Mr. Flower's argument as to the present level of the source of the river was of no weight, as the country in which it had its source was formerly, as now, at a much higher level than the gravel at Downton. As to the absence of marine shells at Cams Wood, he cited a raised beach in Cornwall which, in company with Mr. Jeffreys, he had examined for a mile without finding a trace of a shell, though for the next half mile they abounded. There was the same difference between the raised beach at Brighton and at Chichester. He was obliged to Mr. Codrington for his correction as to the level at Cams Wood, though the pit was at a higher elevation than the one to which Mr. Codrington had alluded.

2. "On some undescribed Fossils from the 'Menevian Group of Wales.'" By Henry Hicks, Esq., F.G.S.

In this communication the author gave descriptions of all the fossils hitherto undescribed from the Menevian rocks of Wales. The additions made to the fauna of the Lower Cambrian rocks (Longmynd and Menevian groups) by the author's researches in Wales during the last few years now number about fifty species, belonging to twenty-two genera, as follows :—

Trilobites, 10 genera and 30 species.
Bivalved and other Crustaceans, 3 genera and 4 species.
Brachiopods, 4 genera and 6 species.
Pteropods, 3 genera and 6 species.
Sponges, 1 genus and 4 species.
Cystideans, 1 genus and 1 species.

By adding to these the Annelids, which are plentiful also in these rocks, we get seven great groups represented in this fauna, the earliest known at present in this country. By referring to the Tables published in M. Barrande's excellent new work on Trilobites, it will be seen that this country also has produced a great variety, or, rather, representatives of a greater number of groups from these early rocks than any other country. The species described included *Agnostus,* 5 species; *Arionellus,* 1 species; *Erinnys,* 1 species; *Holocephalina,* 1 species; *Conocoryphe,* 2 species; *Anopolenus,* 2 species; *Cyrtotheca,* 1 species; *Stenotheca,* 1 species; *Theca,* 2 species; *Protocystites,* 1 species, etc. The author also entered into a consideration of the range of the genera and species in these early rocks, and showed that, with the exception of the *Brachiopods, Sponges,* and the smaller *Crustacea,* the range was very limited.

A description of the various beds forming the Cambrian rocks of St. David's was also given, and proofs adduced to show that frequent oscillations of the sea-bottom took place at this early period, and that the barrenness of some portions of the strata, and the richness of other parts, were mainly attributable to these frequent changes.

Discussion.—Mr. Gwyn Jeffreys suggested that the term Polyzoa might be adopted in preference to that of Bryozoa, as being the more ancient term, and that the name *Proserpina* should not be applied to the new genus of Trilobites, as it had already been appropriated to a tropical form of land-shell.

Mr. Hicks thanked Mr. Jeffreys for his suggestions, which he was inclined to adopt.

Geologists' Association.—1st December, 1871.—The Rev. T. Wiltshire, M.A., F.G.S., President, in the Chair. The following paper was read: "On the Glacial Drifts of North London." By Henry Walker, Esq.—These drifts were described under the classification and nomenclature given to the Glacial deposits by Mr. Searles V. Wood, jun. They were traced from East End (Highgate) and Muswell Hill to Finchley, Colney Hatch Lane, and Whetstone. The profusion of chalk found in the Glacial clay at these places bears out the designation of the main deposit in South-eastern England as the great Chalky Boulder-clay; but it is also found that the sands and gravels of the Middle Glacial, which Mr. Wood seems to restrict to a much lower horizon than Finchley, are also to be found at these localities. At Whetstone the Chalky Boulder-clay is found overlying twenty-five feet of gravel and sands; and in the apparently corresponding beds at Finchley and Hendon Lane drift fossils and casts are occasionally found.—Dr. Hicks agreed with the conclusion that these sands and gravels are Mr. Wood's Middle Glacial.—Mr. Caleb Evans thought the heights to the north of London marked the southern termination of the Glacial drifts.—Mr. Bott considered that the Glacial sea had extended over the country south of the Thames.—Collections of fossils and boulders from the Drift of Middlesex were exhibited, and Mr. J. T. B. Ives drew the attention of the meeting to a quantity of peat which he had taken from the Drift.—At the next meeting of the Association, 5th January, 1872, a paper will be read "On the Overlapping of several Geological Formations on the North Wales Border." By D. C. Davies, Esq., of Oswestry.

CORRESPONDENCE.

LOCAL MUSEUMS AND SCIENTIFIC SOCIETIES.[1]

Sir,—I am glad to see in the November Number of the Geological Magazine, that my suggestions with regard to Local Museums are seconded by Mr. Townshend M. Hall.

If the British Association had for its object something beyond the reading of scientific papers and discussions thereupon, part of its energies might be well expended in giving an impulse to scientific investigation in the several localities it annually visits. The value of individual labour in the cause of science would be greatly enhanced by the development of scientific organization throughout the country, *i.e.*, by the development of the proper functions of local scientific societies and museums. The result would be a greater national appreciation of the importance of scientific investigation as it relates to this country; science would meet with greater support, and the valuable private local collections of Geology, Natural History, and Archæology, would often eventually be added to the several museums to which they would locally belong. The museums would rise from their present debased position as curiosity shops, and would become valuable storehouses for the benefit of science and posterity. But this desirable state will not be arrived at so long as societies are isolated, and have merely local journals of proceedings. It is needless to say what important results might arise from their uniting their observations in a common journal of science. The present system of societies throughout the kingdom is like a vast machine, of which the wheels are unconnected; unite them, and the results might be gigantic.

Scientific societies should always be in connexion with a local Museum, for the development of which the members should individually labour in their several departments. Private collections if undertaken with any energy soon become an incumbrance. Unfor-

[1] See *Nature*, vol. v., p. 35.

tunately the present museums are in such a state of neglect from the want of competent curators, and from the apathy and ignorance of committees connected therewith, that they render the formation of local collections waste of time and energy, as they are unfitted for their permanent and efficient preservation.

Scientific men seem frequently to be so much engrossed in their own departments that the result is, the general interests of science are neglected. This want of public spirit is much to be regretted; not to mention the jealous spirit too often exhibited, and their acting, in some instances, as if they had taken leases of certain departments of Nature, and had set up a notice "Trespassers Beware."

I may mention that a museum in London, as a centre of the provincial museums, would be a great requirement, representing an epitome of the collections throughout the country, and of British Geology, Natural History, and Archæology. This should be the British Museum. *British* not in a national, but in a scientific sense. The more appropriate term for the present British Museum would be the "National Museum"; and it should confine its collections more especially to the productions (Natural History, etc., and Antiquarian) of foreign countries. F. G. S.

November 17*th*, 1871.

GREENLAND METEORIC IRON.[1]

Sir,—When reading Mr. Forbes's account of the meteoric iron, whose occurrence on the shore of Greenland was communicated to the Geological Society on the 8th November, the same idea which was expressed by Professor Ramsay occurred to me before I had got as far as his remarks, viz., the idea that this native iron, instead of being derived extraneously from the fall of a meteorite, might be a portion of a "metallic core of the earth, brought to the surface by the eruption of the basalt in which it is said to be imbedded."

But upon consideration this seems extremely unlikely. Nothing is more certain than that the earth consists of concentric spheroidal strata, each stratum being of equal density throughout. And since the mean density of the whole is fully twice the mean density of the surface, it follows that there must be strata of great density within. Now such being the case, it seems not to admit of doubt, that the more dense strata will be there more deeply situated. When, then, we consider the relative densities of meteoric iron, which is about 7·7, and of basalt, which is about 3, it seems highly improbable that they should be sufficiently nearly associated in the interior for the heavier one to have been raised to the surface entangled in the lighter. Nevertheless a terrestrial origin appears to me possible.

From the analogy of meteoric stones, it seems very probable that our earth may possess a central core of iron. Those bodies are, as is well known, divisible into stony and metallic. The former nearly resemble our crystalline rocks, and the latter consist principally

[1] Other letters have been received on this subject from Colonel Greenwood and F. G. S., but want of space precludes their publication till next month.

of metallic iron. If, as is surmised, these are portions of a shattered planet (or of more than one such planets), then that planet must have consisted of a metallic core, surrounded by a stony envelope, affording a presumption that ours is similarly constituted.

The question may be looked at from another point of view. We know such bodies to be flying about in space; and it is highly probable that our earth was formed out of a conglomeration of them. It seems probable, then, that the materials of the earth were originally mingled fortuitously in a state of fusion, arising from the heat developed by the collision. So long as the heat was sufficiently great to keep the whole in a liquid state, in spite of the pressure arising from the mutual gravitation of the parts, the heavier materials would continue to fall towards the centre, and thus produce a metallic core. But this process would possibly be imperfect in some parts, either owing to the superficial portions being cooled to the limit of the melting point for the pressure too soon for the precipitation to be completed, or perhaps from meteorites arriving afterwards, when the superficial layers had become too viscid for them to sink through to their proper stratum. The subsequent contraction of the whole beneath a cooled crust might, as I have suggested elsewhere,[1] cause subjacent rock to pass into a fluid state, owing to decreased pressure beneath mountain elevations, and thus basalt containing metallic masses might be erupted.

I wish that the report given in the MAGAZINE had described the *forms* of the masses of iron,[2] which I believe are generally of a similar angular character in most meteorites. O. FISHER.

TERRACES IN NORWAY.

SIR,—Allow me to express my regret to Colonel Greenwood for having misunderstood him, and to assure him that I did not write without his letters before me. The mistake, which I now see to be my own, was partly due to my not understanding the word "inland" in exactly the same sense as he had done,—a misunderstanding caused to some extent by my experience in Norway, where terraces which he would call "marine" occur some distance away from the sea; his reference to Glenroy also helped to increase the confusion. In the other matter, we are using the word "cause" in a slightly different sense. I know, of course, that in one case there is upheaval, in another lowering of the river bed, but each makes the water run quicker, and that—the running water—I have called the cause. With this expression of my regret, both for having misunderstood Colonel Greenwood and for being still unable to accept his theory, I must occupy no more of your space on this matter.

T. G. BONNEY.

[1] Cam. Phil. Trans., vol. xi., part iii.; and GEOL. MAG., Vol. V., p. 493, and Vol. VI., p. 45.

[2] Nearly every *stone* meteorite preserves its true external dark vitrified coat; but meteoric iron corrodes and rusts so rapidly on its exterior, that the original form of the mass is seldom preserved.—EDIT. GEOL. MAG.

A. T. Hollick del. et lith. Mintern Bros imp.

Fossil Ferns

THE

GEOLOGICAL MAGAZINE.

No. XCII.—FEBRUARY, 1872.

ORIGINAL ARTICLES.

I.—Notes on some Fossil Plants.

By William Carruthers, F.R.S., etc.

(PLATE II.)

IT is known that the friends of the late distinguished palæontologist and naturalist, Hugh Falconer, established a Fellowship in memory of himself, and in connexion with the University of Edinburgh. This Fellowship is especially intended to encourage the study of palæontology. To give to botanical students who may devote their attention to the investigation of fossil plants a fair opportunity of securing a Falconer Fellowship, Professor Balfour intends, as he informs me, to devote more time in his lectures to vegetable palæontology, and he has prepared a carefully revised and enlarged edition of that portion of his Class-book devoted to this subject, which will be published separately, and will supply a long desiderated manual, not only to the students of his own class, but to students in all institutions in which botany is treated in a scientific method. Having obtained Prof. Balfour's permission to use one of the plates and some wood-cuts which have been prepared under my direction, to illustrate this separate publication, I now employ them for the purpose of recording some notes bearing upon the subjects figured, and which I have not yet published.

1. *Palæopteris Hibernica,* Schimper.

The Plate selected is devoted to fossil Ferns. The principal figure is a restoration of a frond of the Devonian Fern, first recognized in the Yellow Sandstones of the South of Ireland, and named by Edward Forbes *Cyclopteris Hibernica* (Brit. Assoc. Rep., 1852, p. 43). He observed that it did not belong to Brongniart's limited genus *Cyclopteris,* but that its large bipinnate fronds had the aspect of a *Neuropteris.* In a letter from Brongniart to Sir Richard Griffith, published in 1857 (Nat. Hist. Rev., vol. iv. Proc. Soc., p. 215), the writer points out the affinities of the Fern to the species included in the genus *Adiantites,* but adds that it is so different from the other species that it forms perhaps a distinct genus. The discovery of fertile specimens finally established the generic distinctness of the

Fern; and Schimper, in his Traité de Pal. Végét. (vol. i. p. 457), proposed the genus *Palæopteris* for this and four other species which he associates with it. He has given an admirable figure of a portion of a frond, and a less correct one, as I believe, of a fertile pinna (pl. xxxvi.). More recently, Mr. Baily has given a restoration of the Fern in his Figures of Characteristic British Fossils (pl. xxviii. fig. 1.) He represents it as a somewhat deltoid frond, 30 in. long by 25 in. broad with 12 pinnæ. The specimens I have examined are much longer in proportion to their width, and agree with the description Schimper gives of their form, that it is broadly ovate-lanceolate. In one specimen in the collection of the British Museum, 19 pinnæ are shown in a length of 2 ft. 4 in., and the fragment is without base or apex. The longest pinna in this specimen is 11 inches.

The stipes were thick, of considerable length, and clothed with large scales, which formed a dense covering at the somewhat enlarged base. The well defined separation which I have observed in several specimens, and which is shown in Mr. Baily's figure, as well as in that which accompanies this paper, probably indicates that the stipes were articulated to the stem or freely separated from it, and some slender root-like structures which occur on the slabs with the ferns may be their creeping rhizomes. The pinnæ are linear, obtuse, and almost sessile. The pinnules are numerous, overlapping, of an ovate or oblong-ovate form, somewhat cuneate below, and with a decurrent base. The veins are very numerous, uniform, repeatedly dichotomous, and run out to the margin, where they form a slight serration. Single pinnules rather larger than those of the pinnæ are placed over the free spaces of the rachis, as was pointed out by Brongniart. I have not met with any recent fern in which this occurs; but it has been observed in several fossil species, as in the allied American *P. Halliana*, Sch., in *Sphenopteris erosa*, Morris, and others.

Schimper describes the fertile pinnules as situated in the middle of the pinnæ, and consisting of numerous pedicellate fascicles of sori, borne on the primary nerve. The sorus, he says, is club-shaped, and the vein on which it is borne is continued to the apex of the segment. In some specimens in the British Museum all the lower pinnæ are entirely fertile. I am satisfied that the ovate-oblong sori are generally single, and not clustered (Fig. 4.), and are two-lipped, the slit passing one-third of the way down the sorus. The vein is continued as a free receptacle in the centre of the cup or cyst, as in existing *Hymenophylleæ*, in which it is included, not reaching beyond its entire portion. In some specimens the receptacle is broad or thick, indicating the presence of something besides itself in the cup, and giving the appearance that would be produced if it were covered with sporangia; I cannot, however, detect any indication on the outer surface which might have been expected from the individual sporangia. The compression of the specimens in the rock, which has made the free receptacle appear like a vein on the wall of the cup, together with the highly altered condition of the rock in which the fossils are contained, account for the imperfect preservation of the minute structures.

The interpretation which I have here given of the fructification of this interesting fossil, exhibits so close a resemblance to what we find in the living genus *Hymenophyllum*, that, were it not for the vegetative portions, I would without hesitation place it in that genus. But inasmuch as the arborescent *Lycopodiaceæ* of the Palæozoic rocks, while agreeing in all the essential parts of their reproductive organs with particular existing genera of the order, as I have elsewhere shown, are properly placed in distinct genera, so this fern, removed in precisely the same way from the known living forms, requires a generic designation. The large size and obviously firm texture of the frond is in remarkable contrast with those membranaceous fronds of the living forms which have secured for them the popular name of "Filmy Ferns." But the New Zealand genus *Loxsoma* has large decompound sub-coriaceous fronds, and though on this account it is a somewhat aberrant form, nevertheless the cup-shaped involucre, free central receptacle, and sessile oblique-ringed sporangia, place it beyond doubt among the *Hymenophylleæ*. In the form of the pinnules, *Loxsoma* is not unlike *Palæopteris*; the venation of the fossil is however more flabellate, and the veins are more numerous and equal-sized; but that there is a true though indistinguishable costa in each pinnule, as in *Loxsoma*, is obvious from the fertile pinnæ, where the pinnule is reduced to the much-enlarged costa with the short veins bearing the cysts. This absorption of the parenchyma in *Palæopteris* is very different from what occurs in *Loxsoma*; but in the small Central American Hymenophyllaceous genus *Feea* we find the fertile frond reduced to its rachis, with a series on either side of short pedicels (representing the costæ of the segments) supporting each a Trichomanoid cyst. The uniform flabellate veins, which suggested to Brongniart the genus *Adiantites*, though not the familiar form of venation in the Filmy Ferns, do occur in some species, especially among the simple fronded forms.

2. *Sporangia of Ferns in the Coal-measures.*

I have met with an interesting confirmation of the existence of true *Hymenophylleæ* in Palæozoic formations in the discovery of Sporangia belonging to this group of Ferns in the Coal-measures. The sporangia are the cases in which the spores are formed. They are divided into two great groups, by the presence or absence of an elastic ring, technically called an annulus. The annulate sporangium consists of a cellular sac, an articulated ring, which is either vertical (*Polypodieæ*), oblique (*Hymenophylleæ* and *Cyatheæ*), or horizontal (*Gleicheniaceæ*), and generally a pedicel. The articulated ring is hygrometrically elastic, and, when the capsule is ripe and the atmosphere dry, it tears the little sac and lays it open with such a sudden spring as to scatter the spores. In the vertical-ringed sporangia, the ring is continued into a long slender pedicel (Fig. 7). Those with oblique rings are attached to the receptacle by the cellular substance of the sac (*Cyatheæ*), or by a short thick pedicel developed from the sac (*Hymenophylleæ*), Fig. 6. The sporangia which I have obtained in sections of calcareous nodules from the Coal-measures at Oldham (Fig. 5), prepared by Mr. Norman, have all the characters which I have given as characteristic of those of *Hymenophylleæ.* They are larger than the sporangia of *Polypodium vulgare* (Fig. 7), and even than those of *Hymenophyllum Tunbridgense* (Fig. 6), but they agree with them in their form, the nature and position of the ring, and the form of the pedicel. I cannot venture to co-relate them as yet with any fern of the Coal-measures, but I trust that a more careful examination of Carboniferous ferns may lead to the detection of fertile specimens of this type.

3. *Osmundites Dowkeri,* Carruthers.

A transverse section of the stem of a Royal Fern (*Osmundites Dowkeri,* Carr.), from the Lower Eocene of Herne Bay, is given in Fig. 8. This has been already figured and fully described in the Quart. Journ. Geol. Soc. 1870, p. 349, pl. xxiv. and xxv. The section shows the slender axis surrounded by the bases of the stipes, each with its unbroken lunate vascular bundle. The tissues are so beautifully preserved that even the starch grains filling some of the cells are silicified, as well as the ramifying mycelium of a fungus which had attacked the fern (Fig. 9). No foliage has been found in Eocene beds at Herne Bay, but the peculiarities of the stem structure are fully sufficient to establish the affinities of this fossil.

4. *Antholithes,* Brongn. *Cardiocarpon,* Brongn.

The name *Antholithes* was proposed by Brongniart (Mem. du Mus. d'Hist. Nat., vol. viii., 1822, p. 319) for two forms of detached flowers from Monte Bolca, which he thought were referable, the one probably to *Liliaceæ,* and the other to *Nymphæaceæ.* A very different plant-fragment from Carboniferous rocks was referred by Lindley to the same group with the Eocene flowers, under the name of *A. Pitcairniæ* (Foss. Flor., 1833, pl. 82). The remarkable caution of this distinguished botanist is in striking contrast to the dogmatic assertions of some students of Palæontological Botany who have followed him. He says: "This is beyond all doubt the remains of the inflorescence of some plant, but it would puzzle the most ingenious speculator to find a single character in the fossil upon which a positive opinion as to its original nature can be formed. . . . All that can be said is that there is a tolerably distinct appearance of a calyx, which seems to have inclosed petals much longer than itself; this taken together with the probability that it owes its preservation to its having been originally of a hard and indestructible texture, has induced us to name it as if it had been allied to some of the recent tribe of Bromelias, to which, especially the genus *Pitcairnia,* it has as much resemblance as to anything else." In 1840 Mr. Prestwich, in his well-known Memoir on Coalbrook Dale (Trans. Geol. Soc., 2nd ser., vol v., pl. xxviii., fig. 5), gave drawings of another fossil allied to *A. Pitcairniæ,* which was described by Professor Morris under the name *A. anomalus,* and characterized as having the "calyx apparently shorter than the petals (?), furnished with a small lanceolate bract, stigma, or carpella (?) bilocular, elevated upon a long curved filament." These filamentous appendages, he rightly considered as opposed to the notion that the fossils were related to *Bromeliaceæ*, and he suggested comparisons with *Orobanche, Hedychium*, and *Lacis*.[1]

Göppert, in his Permian Flora, figures an Antholite (pl. xxi., fig. 1–3), which he considers to be the inflorescence of *Nöggerathia*, a genus placed by him among the monocotyledons; while Ettingshausen, on the other hand, believes the forms he found in the Coal-Measures at Stradonitz to be the fruits of *Calamites* (" Steinkohlenflora Stradonitz," pl. v., fig. 1–3). He describes the bracts and fruits as borne in an opposite and alternate manner on the common peduncle, overlooking the structural consideration that the phyllotaxy of *Calamites* demands a verticillate arrangement in the floral spike. Principal Dawson figures several forms in his " Memoir on the Conditions of the Deposition of Coal " (Quart. Journ. Geol. Soc., 1866, pl. vii., fig. 29 and 30), and two additional forms from Devonian strata in his Acadian Geology (p. 555, fig. 194 *e* and *f*). One of the latter, *Trigonocarpon racemosum*, Daws., is figured with sessile (Acad. Geol. l.c.) or with shortly pedicellate fruits (Foss. Pl. of Devon. and Sil. Form., 1871, pl. xix., fig. 227*a*). A fragment of a fossil with sessile fruits is figured in Prestwich's Memoir, to which I before alluded (Geol. Trans., ser. 2, vol. v., pl. 38, fig. 5, specimen furthest to the right). I have made a drawing of a similar sessile-fruited Antholite in the Museum at Manchester, but I have not been able to re-examine the fine series of Antholites in that Museum in connexion with my present inquiry. It appears, therefore, that some Antholites had sessile fruits, and it is very probable, as Dr. Dawson believes, that these may be the peduncles of different species of *Rhabdocarpos* and *Trigonocarpon*. But that these spicate inflorescences and their fruits belong to *Sigillaria*, is opposed to the observations of Goldenberg, which have been confirmed by subsequent observers, as well as to the analogy of the fructification of the other closely related Carboniferous *Lycopodiaceæ*.[2]

Besides these sessile-fruited Antholites there is another group, including in it the two British Carboniferous forms to which I have

[1] There is a group of Carboniferous fossils having remarkable amorphous outlines which so resemble the vegetative portions of the *Podostemmaceæ* (to which *Lacis* belongs) that I have for some time been looking out for evidence to confirm or set aside my suspicion that they belong to this order. The plants to which I refer are mostly included in Schimper's genus *Racophyllum* (Traité Pal., vol. i., p. 684), and supposed by him to be the primary fronds of ferns. The physical conditions existing at the time when the shales of the Coal-measures were being deposited would specially suit the habits of this curious order of plants, the foliage of which has the aspect of thallogenous cryptogams, while the reproductive organs are those of dicotyledons.

[2] The phrase "corresponding to" is somewhat vague, but I cannot understand in what sense it is used by Dr. Dawson in the following statement made regarding the Antholite spike in his Memoir already quoted (Quart. Journ. Geol. Soc., vol. xxii., p. 133), and repeated in the second edition of his Acadian Geology (p. 438). "Such spikes may be regarded as corresponding to a leaf with fruits borne on the edges, in the manner of the female flower of *Cycas*." I fail to see that any correspondence can exist between so complex a structure as a primary axis bearing not only its own foliar appendages, but in their axils secondary leaf-bearing and fruit-bearing axes, and the simple open carpellary leaf of *Cycas*.

referred, and which are distinguished by possessing the long linear processes proceeding from the bud, that were supposed by Lindley to be petals, and by Morris as either a style or carpellary pedicel. After examining a large series of Antholites in different museums, and observing the sessile-fruited specimens in the Manchester Museum, I had come to the same conclusion with Prof. Morris, that they were styles with somewhat dilated stigmas, and I saw reasons for co-relating them with the *Orobancheæ.* This opinion I communicated to Sir Charles Lyell, and it was introduced by him, on my authority, into his Students' Manual (p. 412). But this work had scarcely issued from the press when Mr. Peach submitted to me some important specimens which he had discovered in the Carboniferous shales near Falkirk. These threw a new light on the nature of the processes exserted from the axillary bud, and showed that they were, as Morris had suggested, pedicels of fruits. The specimens described by Morris were somewhat obscure; but there can be no doubt about those belonging to Mr. Peach,[1] and the information they give clears up the obscurities of the earlier specimens. I have been still further aided by a specimen of *A. anomalus,* Morris, in the British Museum, preserved in an ironstone nodule like those from Colebrook Dale, but said to be from Derbyshire. This specimen still retains somewhat of its original bulk, but the tissues have disappeared, and the space occupied by them is filled with a little carbonaceous matter, but chiefly with crystals of calcite or with allophane.

When Brongniart, in the infancy of Palæontological Botany, proposed the name *Antholithes,* he included in the group to which he applied it two fossils that belonged, as he believed, not only to two different orders, but to orders so widely removed from each other that the one is monocotyledonous and the other dicotyledonous. This cannot of course be accepted as a generic group. Such vague terms as this and *Phyllites, Carpolithes,* etc., were at the time necessary; but it is obvious that they must be set aside, in regard to one or more of the objects included under them, as soon as, in the progress of investigation, the true nature of these objects is ascertained. There is the less reason for hesitating to set aside the familiar name *Antholithes,* in the case before us, inasmuch as the fruits which Prof. Morris and Mr. Peach have found associated with these fossils have received the characteristic generic name of *Cardiocarpon.* As one of the names must be suppressed, it is obviously desirable to place that one among the synonyms which is in its very nature temporary, and not truly generic. Besides, the Carboniferous species could not now be included under the same generic designation with the Eocene flowers.

The genus *Cardiocarpon* was established by Brongniart (Prod. p. 87) for several lenticular, compressed, obcordate or reniform, and acuminate fruits, which occur in the Coal-measures. He considered them to be the fruits of Lepidodendroid plants, and in this opinion he was followed by Unger and Endlicher. He enumerates five species, but gives no descriptions whereby they can be identified. Lindley and Hutton

[1] These specimens are now in the collections of the Geological Department of the British Museum.

(Foss. Flora, pl. 76) maintained that they were true fruits, but they were not able to indicate their affinities. Göppert and Berger (De Fruct. et Sem. Form. Lith. p. 15) make them dicotyledonous fruits of doubtful affinity; and Dawson, in his recently-published Memoir on Pre-Carboniferous Plants (p. 61), advocates their being gymnospermous seeds.

The materials to which I have referred enable me to give the following description of the genus:—*Cardiocarpon*, Brongn., Prod. (1828) p. 87. *Antholithes*, Lindl. and Hutt., Fossil Flora, pl. 82 (non Brongn.).

Fig. 1. *Cardiocarpon Lindleyi*, Carr. Coal-measures, Falkirk.

Main axis of the inflorescence simple, stout, and marked externally with interrupted ridges. The base is always broken off with an irregular margin, and without any indications of an articulating surface. The axis bears in a distichous manner sub-opposite or alternate bracts of a linear or linear-lanceolate form and with decurrent base. In the axils of the bracts are developed flower-like leaf-bearing buds, and from them proceed three or four linear pedicels which terminate upwards in a somewhat enlarged trumpet-shaped apex. To this enlarged articulating surface was attached the fruit to which has been given the generic name *Cardiocarpon*. The place of attachment is indicated by the short straight line which separates the cordate lobes at the base of the fruit. The fruit is flattish, broadly ovate, with a cordate base and subacute apex. It consists of an outer pericarp, inclosing an ovate-acute seed. That the pericarp was of some thickness, and formed probably a subindurated rind, is shown by a specimen preserved in the round in the collections of the British Museum. A specimen somewhat similar to this is that to which Göppert and Berger have given the name *C. operculatum* (l.c., p. 23, pl. ii., fig. 21); it has lost from the figured side the perisperm, and has the seed exposed. In the figures and descriptions of this and other species of *Cardiocarpon* by these authors the fruits are turned upside down. The pericarp is dilated around the margin of the seed, and gives to the compressed fruit the

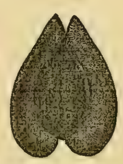


Fig. 2. *Cardiocarpon Lindleyi*, Carr. Twice the natural size.

appearance of being possessed with a marginal wing. This marginal dilatation returns to the seed at the place of attachment of the pedicel, and produces in this way the cordate base which is characteristic of the fruits. The pericarp is also open at the apex; and the elongated tubular apex of the perisperm passes up to this opening. The seed forms a distinct swelling in the centre of the fruit, and a slight ridge passes up the middle to the base of the apical opening.

In endeavouring to interpret the meaning of these structures, we find that there are some points about which there still exists great obscurity. First, what is the nature of the leaf organs of the axillary bud? Are they the parts of a floral envelope, as was supposed by Lindley and Hutton? The specimens are generally preserved in shale as flattened carbonized impressions, so that it is very difficult to determine with anything like precision the arrangement of the parts. They appear to me to be leaves spirally arranged on a shortened axis; and this opinion is strengthened by Mr. Prestwich's drawing of the species described by Prof. Morris, and by a specimen of the same species in the British Museum, in both of which the axis is considerably elongated, and the leaves rise at different levels from the elongated axis. The fruit pedicels spring from among the leaves, and apparently terminate the axis; but it is probable that they are axillary to the foliar organs. The fact that several pedicels spring from each bud is opposed to the notion of the foliar organs being parts of a floral envelope.[1] There are no appendages to the apex of the fruit, and I can detect no scars of appendages at the base where the pedicel is articulated to the fruit. It appears to have been achlamydeous, and was probably also diœcious. The aspect of the fruit as it is ordinarily preserved agrees remarkably with that of a single fruit of *Welwitschia*. It has an apparently winged pericarp, inclosing a seed, the integument of which is produced into a styliform process, that passes through a canal in the pericarp. But the thickened pericarp suggests a Taxineous fruit, with which, from the description I have given, it will be seen that it has many points in common. In *Taxineæ*, however, the fruit is terminal, generally solitary and sessile, with a more fleshy pericarp. On the whole, I am inclined to consider *Cardiocarpon* as a Gymnosperm of an extinct type, confined as far as is yet known to the Palæozoic rocks.

There are two easily distinguished species of *Cardiocarpon* found in British rocks associated with spicate inflorescence. These are:—

1. *C. Lindleyi*, Carr. Woodcuts, Figs. 1 and 2 (*Antholithes Pitcairniæ*, Lindl. and Hutt., Foss. Fl., pl. 82, fig. 2). Spike with sub-opposite axillary axes, bearing four to six lanceolate leaves and three or four pedicels. Primary bracts short and arcuate. Fruit ovate, cordate with

[1] My colleague, Dr. Trimen, has pointed out to me the remarkable fruits of Mr. Miers' genus *Sciadotenia* (Contr. to Botany, vol. iii., p. 340, pl. 138), which are supported on elongated carpophores that are gradually developed beyond the termination of the floral axis, as the fruits advance towards maturity. This singular structure led to a misapprehension of the nature of the carpophores in the first instance, and should modify the general statement I have made above; but inasmuch as we are not likely to find affinities among the *Menispermaceæ* to the plants of the Coal Period, it may be allowed to remain in its present connexion.

an acute bifid apex, and a ridge passing up the middle of the fruit. The following fruits probably belong to this species:—*Carpolithes corculum*, Sternb. Fl. Vorwelt. t. 7, f. 6. *Cardiocarpon apiculatum*, Göpp. and Berg., Fruct. et Sem. Lith., p. 23, pl. ii., fig. 32. *C. operculatum*, Göpp. and Berg., l.c., p. 23, pl. ii., fig, 21. *C. cornutum*, Dawson, Quart. Journ. Geol. Soc., vol. xviii., p. 324, pl. xiii., fig. 23, 24; Pre-Carb. Floras, p. 60, pl. xix., fig. 214–218. *C. bisectum*, Dawson, Quart. Journ. Geol. Soc., vol. xxii., p. 165, pl. 12, f. 73 (conf. fig. 214, Pre-Carb. Floras); Acad. Geol., p. 460, fig. 173*e*. *C. obliquum*, Dawson, Quart. Journ. Geol. Soc., vol. xviii., p. 324, pl. xiii., fig. 25; Pre-Carb. Floras, pl. xix., fig. 225, 226.

The specimen figured was found by Mr. Charles W. Peach, at the Cleuch, near Falkirk, in August, 1870.

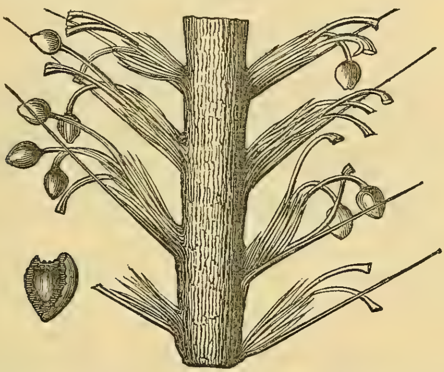


Fig. 3.—*Cardiocarpon anomalum*, Carr. Nat. size, and separate fruit twice nat. size. Coal-measures. Derbyshire?

2. *C. anomalum*, Carr., Woodcut, Fig. 3 (*Antholithes anomalus*, Morris, Geol. Trans., 2nd ser., vol. v., p. 500, pl. xxxviii., fig. 5. Exclude the figure on the right). Spike with alternate or sub-opposite crowded axillary axes, slender and elongated, bearing many linear leaves, and several slender pedicels; primary bracts long, slender, and straight; fruits small, margined. Perhaps *Cardiocarpon acutum*, Brongn., in Lindl. and Hutt. Foss. Flora, pl. 76, may be the detached fruits of this species. The base of the spike is drawn in the accompanying wood-cut; the principal figure in the plate accompanying Mr. Prestwich's Memoir exhibits a considerable portion of its upper part. The detached fruit is twice the natural size. The fracture exposes the seed in the interior, and shows also the thickness of the pericarp, which is always flattened in the specimens preserved in shale.

5. *Coniferous Wood.*

The first sections of fossil plants prepared by Nichol when he discovered the method of slicing them for microscopic inspection, were the famous 'Araucarian' trees found in Craigleith Quarry, near Edinburgh. When Lindley described these trees in his Fossil Flora, he gave reasons for doubting the close affinity which had been assumed between them and Araucaria. And it has always appeared to me doubtful whether the reticulated surface of the wood-cells in these Craigleith fossils was not more nearly allied to the spiral structure found in Taxineous wood, than to the disc-bearing tissue of the *Abietineæ*. The distinction between the two kinds of structure in the wood-cells is well shown in the accompanying woodcut, in which *Pinites Withami*, Lindl. and Hutt. (Woodcut, Fig. 4), is contrasted with a true Abietineous wood from the Wealden at Brook Point, Isle of Wight, (Woodcut, Fig. 5).

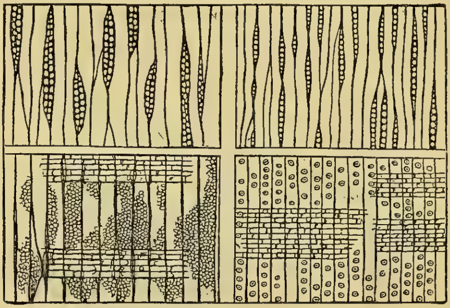


Fig. 4.—*Araucarioxylon* (*Pinites*) *Withami*, Kraus. Coal-measures, Craigleith, Edinburgh.

Fig. 5.—Pine-wood from Wealden at Brook, Isle of Wight.

No fruits have hitherto been found in the Coal-measures which could be referred with certainty to fossils represented by the Craigleith tree, if we except *Trigonocarpon*, which Dr. Hooker has shown good reason for considering a Taxineous fruit. Lindley and Hutton's supposed cone, to which they gave the name *Pinus anthracina* (pl. 164), is certainly a fragment of a Lepidodendroid plant. It is possible that *Cardiocarpon* may have been the fruit of the Taxineous *Dadoxylon*, and that the large *Trigonocarpon* may only be the seed of a large form of *Cardiocarpon*.

6. *Pothocites Grantoni*, Paterson.

Pothocites Grantoni, Paterson. Woodcut, Fig. 6 (Trans. Bot. Soc. Edin., vol. i., p. 45, pl. iii., fig. 1—3), is another remarkable form of inflorescence from the Coal-measures, the affinities of which are clearly investigated by Dr. Paterson in the paper quoted. The original specimen is preserved in the Museum connected with Prof. Balfour's Class-room at the Botanic Garden, Edinburgh, where I have examined it.

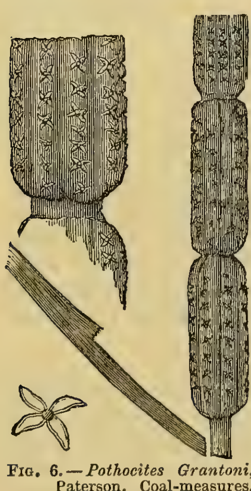


Fig. 6.—*Pothocites Grantoni*, Paterson. Coal-measures, Granton, near Edinburgh.

EXPLANATION OF PLATE II.

Fig. 1.—*Palæopteris Hibernica*, Sch. Restored, one-sixth the natural size. 2. A pinnule, somewhat magnified, to show the venation and slight serration of the margin.—3. Fertile pinna, nat. size.—4. Two cup-shaped involucres attached to the filiform costa, greatly magnified.

Fig. 5.—Sporangia of a Hymenophyllaceous fern from the Coal-measures at Oldham.—6. Sporangia of *Hymenophyllum Tunbridgense*, Sm.—7. Sporangium of *Polypodium vulgare*, Linn.—Figs. 5, 6, and 7 are magnified to the same extent.

Fig. 8.—Transverse section of *Osmundites Dowkeri*, Carr. From the Lower Eocene of Herne Bay.—9. Two cells of this fossil showing the starch granules and mycelium of a fungus still preserved.

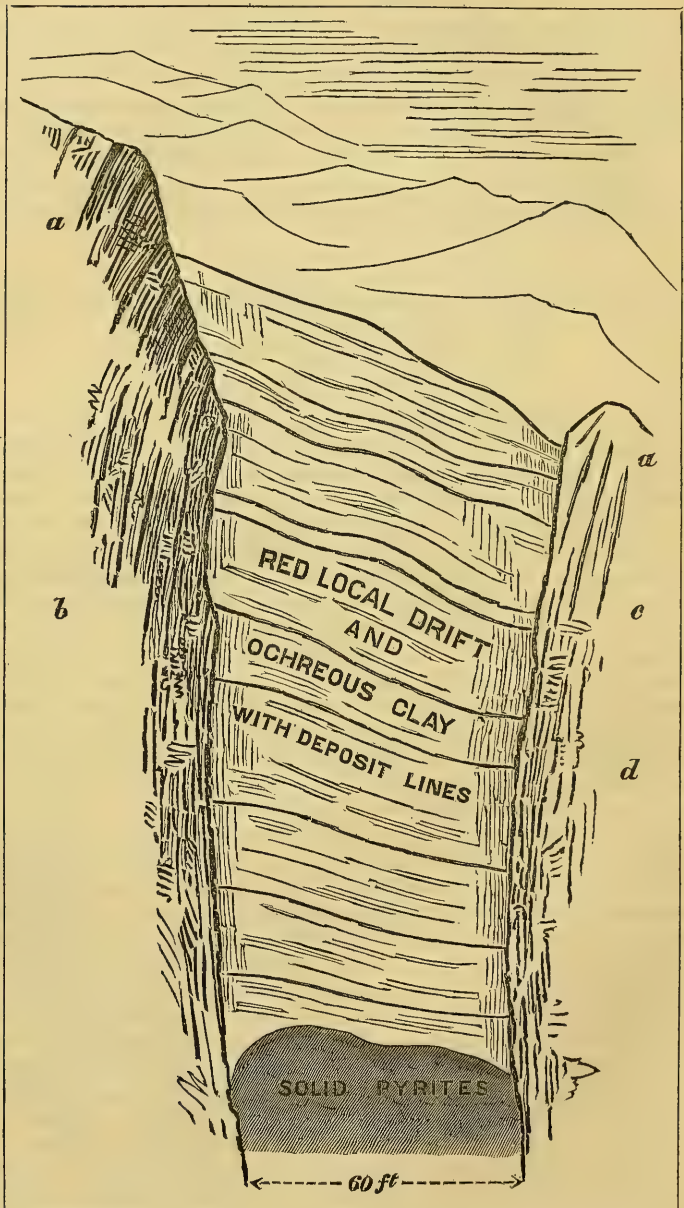
II.—Note on the Pyrites Deposits in the Province of Huelva in Spain.

By S. R. Pattison, F.G.S.

(With a page woodcut.)

THE method now adopted of working the lenticular deposits of pyrites occurring in the province of Huelva by open cutting and quarrying, is favourable to the examination of these singular masses of mineral. The latter run parallel with the strike of the beds; they are generally, but not always, in close proximity to greenstone, the greenstone often forming one wall or *sahlband;* they usually, but not always, decrease in width as they go down, and sometimes end in a boat form; they are generally, but not always, marked by oxidation on the surface, and generally, but not always, by a depression between the two walls. The latter phenomena have been supposed to have been occasioned by the ancient mining for copper having worked away the upper surfaces and exposed fragments of mineral to oxidation; but the facts appear to be at variance with the causes thus assigned, inasmuch as there is extensive colouration where there have been no workings; and on the other hand, no subsidence in many cases where ancient workings exist.

A recent visit to the Buitron mine enables me to offer a few remarks on these deposits. The mass at Buitron occurs in a series of thin-bedded coarse schists, with intercalations of greenstone, the latter ranging with the beds, but occasionally bulging. The mineral does not reach the surface. It appears as though it had been denuded, and had yielded to the denuding force more freely than the sides, which, however, are generally formed of bleached felspathic clay-slate. The skeleton of the mineral mass is a fine siliceous sand, permeated in various proportions with copper, averaging 3 per cent., sulphur, pretty constant at 48 per cent.; and about two shillings worth per ton of gold and silver. Is it not possible that the metals were introduced subsequently to the strata becoming vertical, by sublimation, the chemical action having displaced one substance and deposited another with the silex? There is a kind of grain in the mass of mineral similar to that of any interbedded grit. The overburden, consisting of decomposed "country" reddened by oxide, is only a portion of the adjacent surface rocks, deposited with, if not by, water, in a hollow formed by denudation. The rubble over the mineral



Pyrites Deposit, Buitron Mine, in the Province of Huelva, in Spain.
a, *a*, Sahlband. *b*, decomposed clay-slate. *c* and *d*, greenstone.

is not redder than the purple rocks in the hill above, from which it has apparently descended. It is arranged over the mass in horizontal layers; it is clearly of subsequent and drifted origin. The Roman works which are brought into daylight by the open cutting are exceedingly curious in their character and condition as mining operations. I subjoin a rough sketch of the mass and its overburden at the Buitron mine.

For further notice of these deposits, I beg to refer the reader to Mr. A. H. Green's paper in the *Quarterly Journal of Science*, 1868, vol. v., p. 468, and the authorities there quoted, especially Mr. J. L. Thomas's admirable pamphlet on the mines of Rio Tinto, London, 1865.

III.—On Changes of Climate during the Glacial Epoch.

By James Geikie, F.R.S.E.,
District Surveyor of the Geological Survey of Scotland.

Third Paper.

(*Continued from the January Number, p.* 31.)

In my first paper[1] I gave the sequence of the Scottish Drift under three groups; but in order to compare these deposits more satisfactorily with the drifts of other countries, it is necessary to subdivide them more closely. Briefly tabulated, the order of succession of the Scottish Drifts, beginning with the oldest, is as follows:

Scottish Glacial Deposits.

1. Till with intercalated and subjacent deposits; Boulder-earth and clay	Intense glacial conditions (general ice-sheet), with intervening periods marked by milder climates. The Boulder-earth and clay being partly of land-ice and partly of marine formation, indicates the decrease of the ice-sheets in the later cold periods.
2. Moraine rubbish	Retreat of great glaciers.
3. Kames of sand and gravel	Little or no floating ice; period of subsidence.
4.[2] Brick clays, etc., with arctic and boreal shells; Erratics	Advance of glaciers; period of floating-ice; climate not so intensely cold as during accumulation of Till; re-elevation of the land.
5. Valley moraines.............	Final retreat of the glaciers.

Before proceeding to compare this sequence with that of Scandinavia and Northern Europe generally it will not be amiss to refer in this place to the succession established by the Swiss geologists. According to Mühlberg,[3] the Glacial drifts of the Canton of Aargau are as follows:

Swiss Glacial Deposits.

1. Grundmoräne or moraines profondes	Intense glacial conditions; northern limits of the ice unknown.

[1] See Geol. Mag. Vol. VIII., Dec. 1871, p. 545.

[2] To avoid confusion I have in this table omitted the "high-level beaches," which mark the pauses in the re-elevation of the land. They are referred to in my second paper. I have of course left unmentioned the more recent raised beaches, etc. It is with the Glacial beds proper that I am dealing.

[3] Ueber die erratischen Bildungen im Aargau, etc.; See Nature, vol. ii., p. 310. Mühlberg's results agree with those obtained by M. Morlot, see Edinb. New Phil. Journal, 1855, p. 14, and Antiquity of Man, p. 320.

2. and 3. Moraine rubbish...	Retreat of the great glaciers; erosion of river terraces.
4. Moraines overlaying the older glacial deposits	New advance of glaciers.
5. Newer moraines............	Periodic retreat of glaciers.

The ground moraines are undoubtedly the exact equivalents of our Till. The Scottish drifts marked 2 and 3 correspond to the moraine rubbish of the Swiss section—the difference between the Scottish and Swiss deposits being only what we should expect when we remember the different conditions under which they were separately deposited. The subsidence that drowned a large part of Scotland produced the Kames, which are made up partly of the old moraines (2) and partly of the Till and Boulder-earth or clay (1). In the Swiss section, No. 4 is the terrestrial equivalent of the shelly clays and erratics of the Scottish series. No. 5 is precisely the same both in Scotland and Switzerland. It will be observed that in the ground moraines of the latter country no inter-Glacial beds, such as characterize the Scottish Till, have been observed. But when we consider how great the chances are against inter-Glacial deposits being preserved, the absence of these from the Swiss *Grundmoräne* need not surprise us. It is quite possible, however, that they may exist, although they have not yet been detected.[1] The Scottish Till was studied for many years before its intercalated deposits attracted any attention. Is it too much to say that it may be even so with the Swiss *Grundmoräne?*

The succession of the drifts in Scandinavia also agrees generally with that observed in Scotland, and there is nothing in the descriptions given of the "northern drift" of Russia, Germany, and Denmark which does not fit in to the sequence tabulated above. Putting together the results arrived at by several observers, as Sefström, Berzelius, Murchison, Forchhammer, Lyell, Erdmann, and others, we get the following:

Scandinavian Glacial Deposits.

1. Stony clay, sand and gravel	Intense glacial conditions; general ice-sheet.
2? (Moraines)	Retreat of confluent glaciers or ice-sheet.[2]
3. Ösar or Åsar of sand and gravel...	Little or no floating ice; period of subsidence.
4. Clays, etc., with arctic and boreal shells. Erratics	Advance of glaciers; period of floating ice; climate arctic, but not so cold as (1). Re-elevation of the land.
5. Moraines...............................	Retreat of the glaciers.

I have not been able to satisfy myself as regards the position of the "sand and gravel" of No. 1, and therefore cannot say whether it points to inter-Glacial mild periods, like those of which we find such

[1] In a subsequent paper I shall return to the consideration of the inter-Glacial periods of the Swiss geologists, noticing especially the remarkable results obtained by Prof. Heer, see his Urwelt der Schweitz, p. 484, et seq.

[2] From the descriptions given of some of the ösar or åsar, I strongly suspect that the equivalent of No. 2 in the Scottish section occurs in Sweden; but without a personal examination one can hardly be sure of this. MM. Durocher and Martins distinguish two kinds of ösar—the one containing scratched stones and sometimes shells of Arctic species, and being often made up of very coarse materials; the other being more sandy and showing shells of Baltic species. The former may possibly represent some portion of the Scotch Boulder-earth and clay.

decided evidence in the Scottish Till. The "stony clay" is undoubtedly the same deposit as our Till; but it is possible that some of the "sand and angular gravel," associated with the "Rullesteensler" of Scandinavian geologists, may represent No. 2 of the Scottish section. The ösar or åsar agree precisely with our Kames. They are composed of water-worn detritus, gravel or sand, or both. Sometimes the ingredients are fine, sometimes very coarse. Murchison describes large tracts of northern Russia as covered with wide expanses of undulating sandhills; and these occur also in Northern Germany and in Denmark. Occasionally shells are obtained in this drift; those of the Danish drift being of the same species as now occupy the adjoining seas. The same would seem to be the case with some of the Swedish åsar. Sir C. Lyell mentions the occurrence of a ridge of gravel near Upsala which showed a bed of marl made up of the remains of "the mussel, cockle, and other marine shells of living species, intermixed with some proper to freshwater." Several huge erratics lay upon the top of this ridge. All the observers agree that the dispersion of the large angular erratics took place after the accumulation of the ösar, for everywhere the big blocks rest upon these hills of pebbles and sand, an appearance which is common to Russia, Germany, and Denmark, no less than to Scandinavia. Here, then, the phenomena are precisely the same as we meet with in Scotland, and the conclusion seems irresistible that the åsar were accumulated during a temperate condition of things, and while the land was sinking, and that the erratics only began to be dispersed from the Scandinavian mountains when the subsidence had become considerable, and the glaciers consequent upon an increase of cold had entered the sea. The clays with Arctic shells (No. 4) are the representatives of the Scottish shelly clays; and, like them, give evidence of floating ice. The moraines (No. 5) are, of course, much larger than their Scottish equivalents, but they tell exactly the same story.

The Glacial deposits of North America give a similar succession, with the addition of some interesting details. And as these throw considerable light upon the character of those changes that followed upon the withdrawal of the great ice-sheets, I shall refer somewhat more fully to the American drifts than I have done to the Glacial deposits of Europe.

The lowest Glacial deposit recognized by Canadian and American geologists is "unstratified boulder-clay," or "unmodified drift." In some places this deposit is found to overlie beds of sand, gravel, and clay, and these beds have occasionally yielded vegetable remains. Dr. Dawson cites[1] the case of "a hardened peaty bed which appears under the Boulder-clay on the north-west arm of the River of Inhabitants in Cape Breton." "It contains many small roots and branches apparently of coniferous trees allied to the spruces." In an interesting paper by Mr. C. Whittlesey (*Smithsonian Contributions*), reference will also be found to the occurrence below and in the "unmodified drift" of decayed leaves and the remains of the Mas-

[1] Acadian Geology, p. 63.

todon and Elephant. Generally speaking, however, the "unmodified drift" appears to rest directly upon the rocks, which are polished and striated below it. But over wide regions in Labrador, Canada, and the New England States, the lowest member of the drift series is entirely absent; either because it never was deposited, or else, having been laid down, it has subsequently been removed by denudation. Dr. A. S. Packard says, "Nowhere did I see on the coast of Labrador any deposits of the original Glacial clay or unmodified drift. Upon the sea-shore it has been remodelled into a stratified clay, and the boulders it once contained now form terraced beaches."[1] Professor Hind, however, mentions its occurrence capped by sand and forming banks "rising seventy feet above the level of the Moisie River, twenty miles from its mouth." Thick masses of it are encountered in Maine, where it presents precisely the same character as in Scotland—a tough, unstratified clay, crammed with angular and subangular, smoothed, and striated stones. In the State of New York it is described as "sometimes loose but frequently partially aggregated by argillaceous matter that renders a pick necessary to dig it."[2] Mr. Whittlesey also makes frequent reference to the occurrence in Michigan and Ohio of a deposit which he calls "Hardpan," a firmly-compacted "mixture of clay, sand, and gravel, or fragments of rocks in a confused or imperfectly stratified condition."[3] This deposit I conjecture to be the same as our "Till." In the regions described by Mr. Whittlesey it is always associated with freshwater beds, and is included by him among the Glacial drifts.

The same geologist describes the occurrence of freshwater beds, below glacial clay with boulders and sand and gravel. The freshwater beds contained remains of white cedar, pine, spruce, willow, and other varieties not yet determined, and passed down into laminated clays and "hardpan." He gives several sections to show the character of these beds, of which the following is an example:

Artesian Well, Columbia, Ohio.

Surface 215 feet above Lake Erie and 780 feet above tide.

1.	Soil	4	feet.
2.	Sand gravel and boulders	10	„
3.	Coarse sand	2	„
4.	Blue clay and boulders	4	„
5.	Fine quicksand	2	„
6.	Blue clay, inclosing a log	17	„
7.	Hardpan	3	„
8.	Quicksand	1	„
9.	Hardpan to cliff limestone	37	„
		80	„

Sometimes the vegetable remains in the freshwater beds are so plentiful as to vitiate the water-supply. With the above section it is interesting to compare the "journals" of borings made through

[1] On the Glacial Phenomena of Labrador and Maine.
[2] Geology of New York, part iv., p. 160 (Prof. W. Mather).
[3] Smithsonian Contributions to Knowledge, vol. xv.

the drifts in the neighbourhood of Glasgow. Mr. J. Bennie gives,[1] amongst a number of others, a section of the "surface" at Blairdardie, which is as follows:—

1. Surface soil	4½	feet.
2. Blue clay	9	„
3. Hard stony clay (Till)	69	„
4. Sand with a few shells	3	„
5. Stony clay and boulders (Till)	46½	„
6. Mud and running sand (quicksand)	11	„
7. Hard clay, boulders, and broken rock (Till)	27	„
	170	„

Mr. Whittlesey figures a section taken quite close to Lake Michigan, which shows the following succession. (The thicknesses are not given.)

Red clay and red hardpan.
Yellow sandy clay.
White and purple clay, mixed colours in part.
Gravel.
Blue laminated clay passing down into purple hardpan [apparently very thick].

The State geologists of Illinois[2] give the following section of the drift afforded by a shaft sunk in the city of Bloomington:

1. Surface soil and brown clay	10	feet.
2. Blue clay	40	„
3. Gravelly hardpan	60	„
4. Black mould, with pieces of wood, etc.	13	„
5. Hardpan and clay	89	„
6. Black mould, etc.	6	„
7. Blue clay	34	„
8. Quicksand, buff and drab in colour, and containing fossil shells	2	„
9. Clay shale (Coal-measures)		
	254	„

I have referred to these American sections because, as it seems to me, they are in all probability the equivalents of the inter-Glacial deposits of the Scottish Till. It is quite clear from Mr. Whittlesey's paper that the freshwater beds with organic remains are of older date than the mounds of sand and gravel and erratic blocks which overlie the unmodified drift; and Mr. Whittlesey himself believes the plants to represent the flora that characterized North America during or previous to the Glacial epoch. Dr. J. S. Newberry, referring to these and similar phenomena, says, "It has long been known that, in many parts of the valley of the Mississippi, wells penetrating twenty, thirty, or more feet, the superficial formations of drifted materials, clays and sands, with gravels and boulders brought from the far north, encounter sticks, logs, stumps, and sometimes a distinct carbonaceous soil." These vegetable remains, he continues, "form a distinct line of demarcation between the older and newer drift deposits. In or above the horizon of this ancient soil have been found numerous animal remains, *Elephas, Mastodon, Castoroides* (the great extinct beaver), and some others."[3]

[1] On the Surface Geology of the District round Glasgow, etc. Glasgow Geol. Trans. vol. iii., part i.
[2] See Geology of Illinois, vol. iv., p. 179. The "shells" are of fresh-water species.
[3] See Nature, June 22, 1871, p. 155.

The withdrawal of the great ice-sheet was marked, as in Switzerland, by the accumulation of immense piles of moraine rubbish, which are partially re-arranged or "modified," as Professor Hitchcock has it, "by the action of water."[1] It is thus difficult sometimes to distinguish true moraine drift from the re-assorted marine drift,—the one, in short, seems to shade into the other. This, however, does not mean that the deposition of the moraines and their re-assortment by the sea took place at one and the same time. The ice may have melted away from all the low grounds of New England and shrunk back to the valleys among the White Mountains before subsidence of the land began.

In reading descriptions of the mounds of gravel and sand which cover large tracts of country in the New England and the North-western States and also in Canada, one cannot fail to notice how closely all the appearances coincide with those we are familiar with in this country. Professor Hitchcock, describing the drifts of New England, says, they "form ridges and hills of almost every possible shape. It is not common to find straight ridges for a considerable distance. But the most common and most remarkable aspect assumed by these elevations is that of a collection of tortuous ridges and rounded and even conical hills with correspondent depressions between them."[2] This description would apply word for word to some of the larger areas of Kames in Scotland. The American mounds and cones are almost invariably composed of well water-worn materials, usually gravel and sand; and they are, moreover, not infrequently false-bedded. Occasionally boulders are found inside these mounds, but this is certainly quite exceptional, and such included stones are usually more or less rounded. Now and again a mound appears to be composed of coarse shingle and rounded boulders. But when boulders occur in mounds of sand and fine gravel, they seem to be confined chiefly to the upper parts of the deposits.[3]

Immense numbers of large erratics cumber the surface of the ground in many parts of New England, the North-western States, Canada, and Labrador, and are scattered over the tops and slopes of the mounds and ridges of sand and gravel. Even much further north the same phenomena are so striking as to arrest the attention of the traveller who is not strictly a geologist. I was much interested some years ago in reading the accounts given of the "barren grounds" of North America by various writers who had visited these inhospitable regions. Sandhills and huge erratics appear to be as common there as in the countries further south. Captain Back, who followed the course of the Great Fish River (Back's River) down to the Arctic Sea, gives a very graphic account of the isolated cones and

[1] Smithsonian Contributions. Illustrations of Surface Geology, etc.

[2] Trans. of the Assoc. of Amer. Geol. and Natur. 1840–1842, p. 191.

[3] See Report on the Geology of the Lake Superior Land District, p. 235. Also Geology of New York, part iii., p. 121, where Lardner Vanuxem says, "With some exceptions they (erratics) are generally found upon the surface, frequently upon the tops of hills or on their sides, appearing in almost all their localities as if but recently dropped," etc.

"chains of sandhills" which he saw in several places stretching far away on either side from the river valley. He tells us that "the ridges and cones of sand were not only of great height but singularly crowned with immense boulders, grey with lichen, which assuredly would have been considered as having been placed by design, had not the impossibility of moving such enormous masses proved incontestably that it was Nature's work." This was in 66° N. lat. In another place "the country was formed of gently undulating hills, whose surfaces were covered with large fragments of rock and a coarse gravelly soil."[1] In the "barren grounds" to the west of the bleak country traversed by Back sandhills and huge erratics are equally abundant.[2]

Thus in Northern America, as in the northern latitudes of Europe, we find the ground covered throughout wide areas with groups of kames, eskers, ösar, ridges, mounds, or cones of sand and gravel; and these peculiar hillocks are everywhere dotted over with large erratics in such a way as to show that the sand and gravel must have been deposited and heaped up before the erratic blocks were dropped. And, from the rare occurrence of boulders embedded in the sand and gravel, it is only reasonable to infer that at the time the sand and gravel were deposited there could not have been much ice floating about. It is true that piles and mounds of coarse unstratified débris and boulders are occasionally found associated with the re-assorted drift; but these, according to Professor Agassiz and several other American geologists, are moraines and not the droppings of icebergs. The mounds of well water-worn sand and gravel are singularly free of boulders, except on the outside.

After wide-spread accumulations of sand and gravel had gathered upon the bed of the sea, the climate of the northern hemisphere, which had been moderate during the period of subsidence, again became cold. Fleets of icebergs and ice-rafts set sail from every coast that remained above the sea, and dropped their burdens as they journeyed on. But the bed of the sea was now rising, and a great number of old beaches mark out the successive pauses in the re-elevation of the land. Professor Hitchcock describes many in his paper already referred to. The highest beach he mentions is one in the White Mountains, at a height of 2449 feet above the sea. An-

[1] Narrative of Arctic Land Expedition to the Mouth of the Great Fish River, etc., pp. 140, 346. I cannot refrain from quoting a passage which the geologist will at once recognize as a faithful picture of a highly glaciated land-surface. The scene described by Back was just on the skirts of the barren grounds. "There was not the stern beauty of Alpine scenery, and still less the fair variety of hill and dale, forest and glade, which makes the charm of a European landscape. There was nothing to catch or detain the lingering eye, which wandered on without a check over endless lines of round-backed rocks, whose sides were rent into indescribably eccentric forms. It was like a stormy ocean suddenly petrified. Except a few tawny and pale green lichens there was nothing to relieve the horror of the scene; for the fire had scathed it, and the gray and black stems of the mountain pine which lay prostrate in mournful confusion seemed like the blackened corpses of departed vegetation" (p. 178).

[2] See Sir J. Franklin's "First Journey to the Shores of the Polar Sea;" and his "Second Journey;" also Sir J. Richardson's "Journal of a Boat Voyage through Rupert's Land."

other on the Hoosac Mountain (Massachusetts) reaches an elevation of 2022 feet. In the valley of the Connecticut river a raised beach occurs at 1082 feet above the sea. Many of the raised beaches are strewed with huge boulders, as if these had been stranded by rafts of ice.[1]

During the re-elevation of the land beds of clay accumulated off the coast, and became gradually stocked with shells of an arctic type. These are the "Leda clays" of Labrador and Maine, so ably described by Dr. Dawson, Dr. Packard, and others. It can hardly be doubted that they are the equivalents of the Scottish and Scandinavian shelly clays. The fossils which they contain are very decidedly Arctic in the lower beds, but in the upper beds they give evidence of a gradually ameliorating climate.

Dr. Packard seems, if I follow him rightly, to be of opinion that the Leda clay is older than the ösar, and Principal Dawson inclines, but with some hesitation, to the same belief. It may appear presumptuous in me to differ from these authorities, yet after carefully considering what they have written, I venture to think that the evidence in support of their conclusions is hardly satisfactory. The shelly clays (like those of Scotland) are sometimes covered with deposits of sand and gravel (Saxicava Sands), but there is no proof that these beds are necessarily of the same age as the ösar of the interior of America. In America, as with us, the shelly clays are confined to the maritime regions, and I have found no mention made of ösar or mounds and ridges of sand and gravel overlying them. When it is remembered also that erratics everywhere cap the sand and gravel ridges of the interior, and occur abundantly in the fossiliferous clays of the maritime regions,[2] while they may be said to be absent from the interior of the ösar, we can hardly, I think, escape from these conclusions,—first, that the accumulation of the ösar took place under a milder condition of climate than characterized the deposition of the shelly clays; and, second, that of the two deposits the ösar must be the older. But of course it is quite possible that some of the ösar adjoining the maritime regions may have been formed contemporaneously with the Leda clay, with which some of the old sea-beaches, at all events, must be synchronous. If, therefore, we refer the accumulation of the American ösar to the period of subsidence, and the deposition of the "Leda clay" to the following period of re-elevation, we shall have for North

[1] There is some uncertainty as to the height reached by the sea during the period of subsidence that followed upon the retirement of the ice-sheet. Perched blocks are not always safe guides, as these may sometimes have been stranded along the sides of mountains by glaciers. In many, or rather in most cases, however, they would appear to have been carried by rafts of ice and dropped into their present positions. They seem to give evidence, therefore, that the land subsided to at least 2500 feet below the present level of the sea. But Dr. Packard thinks that some of the high-level terraces described by Hitchcock are not of marine but freshwater origin, and that they are relics of glacial lakes. In this case these terraces would resemble the parallel roads of Glenroy.

[2] So much so indeed as to entitle them to be called "Boulder-clays." They are more or less distinctly stratified, however. (*Packard.*)

America exactly the same succession as we have in Scotland and Scandinavia.

In the valleys of the White Mountains and in those of the Rocky Mountains a number of terminal moraines mark the sites of local glaciers which gradually crept up the valleys and vanished as the cold of the Glacial epoch passed away.

For purposes of comparison I shall now throw into a tabular form the general results obtained from a review of what our friends in America have done in the matter of Glacial geology. This table will show how closely the succession of the drift deposits tallies with that of the equivalent beds in Northern Europe.

North American Glacial Deposits.

1. Unmodified drift with subjacent and intercalated beds[1]	Intense glacial conditions (general ice-sheet), with intervening periods marked by milder conditions.
2. Moraines..............................	Withdrawal of ice-sheet from low grounds.
3. Ösar or ridges of sand and gravel	Little floating-ice; period of subsidence.
4. Leda clay, etc. Erratics	Advance of glaciers; period of floating-ice; climate Arctic, but not so intensely glacial as during accumulation of "unmodified drift"; land slowly rising.
5. Valley Moraines	Final retreat of the glaciers.

It is unnecessary for my purpose that I should refer to the details of the more recent superficial accumulations of North America; it is enough merely to remind geologists that in none of the post-Glacial or recent deposits of North America have any traces been found of a warmer climate than the present. On the contrary, every proof is afforded us that from the close of the Glacial epoch there has been a gradual amelioration of climate down to our times.

In my next paper I shall endeavour to correlate the English and Irish drifts with those of Scotland.

IV.—Heer's Flora Fossilis Arctica.

Communicated by Robert H. Scott, F.R.S., etc.

In vol. ii. of his Flora Fossilis Arctica, Professor Oswald Heer has treated of the Fossil Flora of Bear Island, and shown that it belongs to the Lower Carboniferous Formation, of which it forms the lowest beds (named by him the "Ursa" beds), close to the junction with the Devonian. The Yellow Sandstone of Kiltorcan in Ireland, the Grauwacke of the Vosges, and the southern part of the Black Forest, and of St. John in Canada, belong to the same group. In the summer of 1870 two young Swedish naturalists (Wilander and Nathorst) discovered this same formation in the Klaas Billen Bay of the Eisfiord in Spitzbergen, and brought home fine specimens of *Lepidodendron Veltheimianum*, and *Stigmaria ficoides*. It has also been found in West Greenland, for Prof. Nordenskiold tells us

[1] I would remind the reader of what I have said in the text concerning the evidence for these intercalated beds.

that the Swedish expedition, which went to Disco in the course of last summer, to fetch the meteorite, weighing 25 tons, which he discovered at Ovifak in that island, has brought home fossil plants of true Carboniferous age.

The Carboniferous formation was accordingly extensively developed in the Arctic regions, for it occurs also in the Parry Islands and in Siberia; on the Lena it approaches the Arctic circle. These facts show us that at that epoch there was an abundance of land near the north pole, covered with a vegetation closely resembling that of our own latitudes at the same period. Of 18 species of fossil plants at Bear Island, only 3 are peculiar to it, the others are common to the European localities (such as *Lepidodendron Veltheimianum*, *Knorria imbricata*, etc.); and, from the fact that they are as fine and well developed in the northern as in the southern deposits, it is evident that no great difference of climate could have prevailed between the two localities.[1]

In Spitzbergen we have, besides the Miocene Flora and Fauna, an important Diluvial formation. 132 species of Miocene plants have been found, mostly in Eisfiord (lat 78° N.), but some in King's Bay (lat. 78° 56′ N.). The chief form here is an *Equisetum* (*E. arcticum*); but it is surprising to find a Lime (*Tilia Malmgreni*), an Arbor-vitæ (*Thuites Ehrenswaerdi*), a Juniper, and two Poplars nearly on the 79th parallel of latitude. The Flora of the Eisfiord is much richer, especially that of the black slates of Cape Staratschin, where we find 26 Conifers belonging to the *Abietineæ*, the *Cupressineæ*, and the *Taxodieæ*. Several of these species are represented not only by leaves but by their flowers and fruit. The chief forest trees were a new *Sequoia* (*S. Nordenskioldi*), of which we have leaves, twigs, and seeds; *Libocedrus Sabiniana*, and *Taxodium distichum*. Of the last named the collection contains, not only the twigs clothed with leaves, but the male and female flowers, the scales and seeds; so that not even the delicate catkins are wanting to identify this tree with that which is now growing in the Southern States of America. No one can possibly doubt that the tree grew where its remains are now found. *Libocedrus Sabiniana* is also well represented by its peculiar seeds; it was the most graceful tree in Spitzbergen, and its nearest congeners are now found in Chili. Of other trees, Poplars are the most common, with the Birch, Hazel, and Snowball (*Viburnum*); but we are not so much surprised at finding them as at two large-leaved Oaks, the Ivy, and a Walnut.

This Flora has the greatest resemblance to that of North Greenland, and the other of Arctic localities; but several species extend southwards into Europe. On the whole, this Miocene Flora evidences a far greater contrast of climate between Europe and the Arctic regions at that epoch, than that which prevailed during the Lower Carboniferous period. All the tropical and even sub-tropical

[1] Prof. Heer has worked out this idea very fully in his paper on Bear Island, and traced the alternations of rise and fall of the land, which probably occurred during the latter part of the Palæozoic period.

forms are wanting. These facts show us that great changes of climate must have occurred, and it is interesting to trace when these first began to show themselves.

The Cretaceous Flora of the Arctic regions throw important light on this point, and our knowledge of it has been largely enriched by the discoveries of the Swedish expedition of 1870. When the first volume of the Flora Arctica appeared Prof. Heer could only speak of a few specimens belonging to this epoch, which had been found at Kome, on the north side of the Noursoak Peninsula. Prof. Nordenskiold has, however, paid great attention to these fossils, and has discovered several new localities for them on the north shore of the same peninsula. They are found in black shales, apparently from the character of the fossils, belonging to the Lower Chalk—the Urgonian—for they resemble the Flora of Wernsdorf. Among forty-three species already determined, I find twenty-four Ferns, five Cycads, eight Conifers, three Monocotyledons; only one fragment is dicotyledonous, a Poplar leaf, and it is *the oldest dicotyledonous plant that has hitherto been discovered.* Among the numerous Ferns the *Gleichenia* is the most common type, but *Marattiaceœ* and *Sphenopteris* are not rare. Of Cycads we have *Zamites*, with very fine leaves, and *Podozamites Hoheneggeri* (known from Wernsdorf in the Carpathians). It is striking that Sequoias and Pines appear among the Conifers, approaching closely to Tertiary types.

The plants of the black shales of the south side of Noursoak Peninsula have a different character. Nordenskiold has found them at two points (Atane, and on the shore below Atanekerdluk, the well-known Miocene locality). The number of species is about equal to that found in the Lower Chalk just referred to, but their type is almost totally different, and it indicates that they belong to the Upper Chalk. *Sequoia* again predominates among the Conifers, and we find fortunately cones as well as twigs; with them we find a *Thuites* and a *Salisburea*! Cycads are much less common than in the Lower Chalk, only one (*Cycadites Dicksoni*) having been discovered. Among the Ferns, though these are common (eleven species), we find only two Gleichenias (instead of six); other forms, such as *Marattiaceœ, Adiantum* and *Dictyophyllum,* have disappeared. The predominant forms are Dictolytedons, of which there are twenty-four, of various genera and species; many of them have not yet been absolutely determined. But we find three species of Poplar, one Fig (Leaves and *Fruits*), one *Myrica,* one *Sassafras,* one *Credneria,* with two Magnolias. These facts show us that here, as in Central Europe, the Lower Cretaceous Flora consists principally of Ferns, Conifers, and Cycads; while in the Upper Cretaceous Dicotyledons appear. The climatological changes which produced so important modifications in the types of vegetable life must have been as extensive in high as in lower latitudes. If we examine into the climatic character of the Lower Cretaceous Flora, we find it to be almost tropical, as will be seen from the predominant forms of vegetation. The same is true of the Flora of Wernsdorf in the Northern Carpathians, so that in this respect the Lower Cretaceous Flora resembles the Carboniferous Flora. The comparative rarity of Gleichenias and Cycads, and the disappearance of *Marattiaceæ,* might point to a change of climate for the Upper Cretaceous; but the presence of *Ficus* renders this doubtful, so that we cannot decide whether the change of climate occurred during the Cretaceous or the Tertiary period in Greenland; at all events, the Flora of the former epoch has a more southern character than that of the latter.

Besides these fossils, Nordenskiold has brought over a large series of Miocene plants from various localities. The most interesting of these are from a deposit, which is separated by beds of basalt, some 2000 feet thick, from the lower Miocene plant strata, and which, though still Miocene, are much later in age.

The German expedition has brought from the east coast of Greenland some vegetable fossils, many of which are, however, only undistinguishable carbonaceous traces. Lieutenant Payen, however, brought some specimens from Sabine Island which could be identified. They belong to *Taxodium distichum* and *Populus arctica,* with a fragment which probably belongs to *Diospyros brachysepala.* These trees have been discovered in West Greenland, and the two first named in Spitzbergen also, so that they probably flourished over the entire district from the west coast to Spitzbergen. In his paper on Spitzbergen, Professor Heer had remarked that we might expect to find the plants which were common to the west coast of Greenland and to Spitzbergen, on the east coast of Greenland also. This anticipation has now been confirmed by the discovery of these two species, and it may fairly be expected that the fossiliferous Sandstones and Marls of Germania Mountain in Sabine Island contain many of the missing forms.

V.—Earliest Record of the Occurrence of Meteoric Iron in Greenland.

In the Geological Magazine for December, 1871 (Vol. VIII., p. 570), we reported[1] the return of the Swedish scientific expedition from the coast of Greenland, bringing home a number of masses of meteoric iron, found there upon the surface of the ground, the largest of which was said to weigh 25 tons. In the Report of the meeting of the Geological Society, Dec. 20th, 1871, contained in our present number (see page 88), we give some further particulars relative to this interesting discovery, which has elicited a letter from the Rev. O. Fisher (see Geological Magazine for Jan., 1872, p. 47), and a lively discussion at the Geological Society. We are indebted to R. H. Scott, Esq., F.R.S., for obligingly calling our attention to the account of the original discovery, more than fifty years ago, by

[1] Under Proceedings of the Geological Society of London for Nov. 8th, 1871.

Captain (now General Sir Edward) Sabine, of meteoric iron in Greenland, recorded in the Quart. Journ. of Science, 1819, vol. vii., p. 79, with the analysis of the same, previously published, which we venture to think will prove acceptable information to many of our readers.—[Ed. Geol. Mag.]

Esquimaux Knife from West Coast of Greenland, the blade composed of small pieces of meteoric iron; two-thirds natural size. Presented to the British Museum by Capt. (now General Sir Edward) Sabine, and preserved in the Mineralogical Department.

Extract from "*An Account of the Esquimaux, who inhabit the West coast of Greenland, above the lat.* 76°," by Capt. Edward Sabine, R.A., F.R.S., F.L.S.—Quart. Journ. of Science, vol. vii., 1819, p. 79.

Each of the Esquimaux who visited us on the 10th of August, and I believe each of the others whom we afterwards saw, had a rude instrument answering the purpose of a knife. The handle is of bone, from ten to twelve inches long, shaped like the handle of a clasped knife; in a groove, which is run along the edge, are inserted several bits of flattened iron, in number from three to seven in different knives, and occupying generally half the length. No contrivance was applied to fasten any of these pieces to the handle, except the one at the point, which was generally two-edged, and was rudely riveted. In answer to our inquiries from whence they obtained the iron, it was at first understood that they had found it on the shore; and it was supposed to be the hooping of casks, which might have been accidentally drifted on the land. We were surprised, however, in observing the facility with which they were induced to part with their knives; it is true, indeed, that they received far better instruments in exchange, but they did not appear to attach that value which we should have expected to iron so accidentally procured. This produced some discussion in the gun-room; when it appeared that some of the officers, who had been present in the cabin when the Esquimaux were questioned, were not satisfied that Zaccheus' interpretation had been rightly understood; he was accordingly sent for afresh, and told that it was desired to know what had been said about the iron of the knives (one of which was on the table), and he was left to tell his story without interruption or help. He said it was not English or Danish, but Esquimaux iron; that it was got from two large stones on a hill near a part of the coast which we had lately passed, and which was now in sight; the stones were very hard; that small pieces were knocked off from them, and beaten flat between other stones. He repeated this account two or three times, so that no doubt remained of his meaning. In reply to other questions, we gathered from him that he had never heard of such stones in South Greenland; that the Esquimaux had said, they knew of no others but these two; that the iron breaks off from the stone just in the state we saw it, and was beaten flat without being heated. Our subsequent visitors confirmed the above account and added one curious circumstance—that the stones are not alike, one being altogether iron, and so hard and difficult to break that their supply is obtained entirely from the other, which is composed principally of a hard and dark rock; and, by breaking it, they get small pieces of iron out, which they beat as we see them. One of the men being asked to describe the size of each of the stones, made a motion with his hands, conveying the impression of a cube of two feet; and added that it would go through the skylight of the cabin, which was rather larger. The hill is in about 76° 10′ lat., and 64° ¾′ long.; it is called by the natives Sowilic, derived from *sowic*, the name for iron amongst these people, as well as amongst the southern Greenlanders. Zaccheus told me this word originally signified a hard black stone, of which the Esquimaux made knives, before the Danes introduced iron amongst them, and that iron received the same name from being used for the same purpose. I suppose that the Northern Esquimaux have applied it in a similar manner to the iron which they have thus accidentally found.

We are informed in the account of Captain Cook's third voyage, that the inhabitants of Norton Sound, which is in the immediate neighbourhood of Behring's Straits, call the iron which they procure from the Russians *Shawic*, which is evidently the same word; the peculiar colour of these pieces of iron, their softness, and freedom from rust, strengthened the probability that they were of meteoric origin, which has since been proved by analysis.

Meteoric Iron in North America.—The Northern Esquimaux lately visited by Captain Ross were observed to employ a variety of implements of iron, and upon inquiry being made concerning its source by Captain Sabine, he ascertained that it was procured from the mountains about thirty miles from the coast. The natives described the existence of two large masses containing it. The one was represented as nearly pure iron, and they had been unable to do more than detach small fragments of it. The other, they say, was a stone, of which they could break fragments, which contain small globules of iron, and which they hammered out between two stones, and thus formed them into flat pieces about the size of half a sixpence, and which let into a bone handle, side by side, form the edges of their knives. It immediately occurred to Captain Sabine that this might be meteoric iron, but the subject was not further attended to till specimens of the knives reached Sir Joseph Banks, by whose desire Mr. Brande examined the iron, and found in it more than three per cent. nickel. This, with the uncommon appearance of the metal, which was perfectly free from rust, and had the peculiar silvery whiteness of meteoric iron, puts the source of the specimens alluded to out of all doubt. The one mass is probably entirely iron, and too hard and intractable for farther management; the other appears to be a meteoric stone, containing pieces of iron, which they succeeded in removing, and extending upon a stone anvil.—Quart. Journ. Sc., 1818, vol. vi., p. 369.

NOTICES OF MEMOIRS.

I.—The Fossil Flora of Great Britain.

THE Fossil Flora, by Lindley and Hutton, has been long known as the only general work containing figures and descriptions of the vegetable remains found in a fossil state in this country, and which must always be consulted by every scientific investigator of this subject. Since the completion of the third volume, more than thirty years ago, many important papers have been published on the Palæontological Botany of the British Islands, by Dr. Hooker, Bunbury, Prof. Haughton, Prof. Heer, Carruthers, and others, but no general work or continuation of the Fossil Flora has appeared, a desideratum very much needed, and which it is now proposed shall be supplied.

Mr. Quaritch having recently purchased the copper-plates and copyright of this standard work on the Fossil Plants of Britain, and knowing the extreme rarity of the book, has resolved to produce a fac-simile re-issue of the work, from the original copper-plates. To secure the accuracy of the re-issue, Mr. Quaritch has fortunately secured the aid of Mr. Wm. Carruthers, of the British Museum, to superintend it, whose valuable contributions to Fossil Botany are well known to the readers of the Geological Magazine. In addition to re-editing the original work, Mr. Carruthers will prepare a Supplementary Volume, containing figures (in not less than 40 plates) and descriptions of all the important additions made to the Fossil Flora of Britain since 1837; together with a critical examination of the species in Lindley and Hutton's classic work, and a synopsis of all the known Fossil Plants of Britain, which will bring the whole work up to the state of the science at the present day. The work will be issued in monthly parts, commencing in May next.

II.—Notes of a Visit to Dominica.

By R. J. Lechmere Guppy, F.L.S., F.G.S.

[Proceedings of the Scientific Association of Trinidad, December, 1869.]

HAVING spent a few weeks in Dominica, Mr. Guppy has given us a sketch of the physical structure of the island. His observations are the more interesting as it seems that its geological features have not previously been described. Situated between

Martinique and Guadeloupe, Dominica, like them, is a mass of mountains of volcanic structure. There is little that can be called level land, save the alluvial flats of the larger river valleys. The spurs of the mountains usually come down to the sea, often ending in high cliffs and precipitous headlands.

Immediately at the back of the town of Roseau, the capital of the island, there is a hill called Morne Bruce, composed of volcanic rocks, upon which lies a marine formation, which seems to have been part of an immense fringing reef, which existed when the island was at a lower level by some 300 feet. This coral formation is overlain by more recent volcanic accumulations.

Craters do not seem to occur on the higher mountains, but small volcanic cones, often very perfect, exist on the lower ridges. Most of the rocks are varieties of trachyte.

Sulphur springs are a common feature all over the island, having mostly a high temperature, approaching the boiling point.

The structure of Dominica seems to show that two distinct periods of great volcanic activity occurred, in the interval between which the land was much depressed, and coral reefs were formed upon the previous volcanic accumulations. The species of corals determined are: *Favia ananas*, *F. coarctata*, and *Eusmilia aspera*; there are, however, many others, whose specific names cannot be stated with confidence. Mr. Guppy gives also a list of twenty-two species of Mollusca from the same formation, which is stated to be of Pliocene age.

III.—The Geognosy of the Appalachians and the Origin of Crystalline Rocks.[1]

By T. Sterry Hunt, LL.D.

THE twentieth meeting of the American Association for the Advancement of Science was held at Indianapolis, on the 16th of August, 1871. On this occasion, the retiring President, Dr. Hunt, as is customary, delivered an address, of which the subject chosen was the history of the great Appalachian mountain chain. He remarks that nowhere else in the world has a mountain system of such geographical extent been studied by such a number of zealous and learned investigators, and no other has furnished such vast and important results to geological science.

Dr. Hunt first brings forward certain facts in the history of the physical structure, the mineralogy, and the palæontology of the Appalachians; and, in the second place, discusses the conditions which have presided over the formation of the ancient crystalline rocks that make up so large a portion of this great eastern mountain system.

A section across northern New York, from Ogdensburg, on the St. Lawrence, to Portland, in Maine, shows the existence of three distinct regions of different crystalline schists. These are—(1). The Adirondacks, to the west of Lake Champlain; (2). The Green Moun-

[1] Printed in advance from the Association number of the American Naturalist. 8vo. Salem, 1871.

tains of Vermont; and (3), The White Mountains of New Hampshire.

(1). The Adirondack series, to which the name of the Laurentian system has been given, is composed chiefly of granitic gneisses, which are frequently hornblendic, but seldom or never micaceous. It contains no argillites, which are found in the other two series. The quartzites, and the pyroxene and hornblendic rocks, associated with great formations of crystalline limestone, with graphite, and immense beds of magnetic iron ore, give a peculiar character to portions of the Laurentian system.

(2). The Green Mountain or Huronian series consists largely of a fine-grained petrosilex or eurite; true gneiss, which is ordinarily more micaceous than the typical Laurentian gneiss, also occurs. Massive stratified diorites, and epidotic and chloritic rocks, often more or less schistose, with steatite, dark coloured serpentines and ferriferous dolomites and magnesites, also characterize this gneissic series. These are intimately associated with beds of iron ore, generally a slaty hæmatite, but occasionally magnetite. Chrome, titanium, nickel, copper, antimony, and gold are frequently met with in this series. The gneisses often pass into schistose micaceous quartzites, and the argillites, which abound, frequently assume a soft, unctuous character, which has acquired for them the name of talcose or nacreous slates, though analysis shows them not to be magnesian, but to consist essentially of a hydrous micaceous mineral. They are sometimes black and graphitic.

(3). The White Mountain series is characterized by the predominance of well-defined mica-schists, interstratified with micaceous gneisses. There are also beds of micaceous quartzite. Hornblendic gneisses and schists occur, which pass occasionally into beds of dark hornblende-rock, sometimes holding garnets. Here and there beds of crystalline limestone are also found, and sometimes accompanied by pyroxene, garnet, idocrase, sphene, and graphite. They are intimately associated with highly micaceous schists containing staurolite, andalusite, cyanite, and garnet. To this third series belong the concretionary granitic veins abounding in beryl, tourmaline, and lepidolite, and occasionally containing tinstone and columbite.

Dr. Hunt traces out the geographical distribution of these three groups, and discusses the opinions of different observers in regard to their relative ages. His own conclusion is that the whole of the crystalline schists of eastern North America are Pre-Cambrian in age.

Referring to the evidences of similar rocks in other countries, he states his opinion that the crystalline rocks of Anglesea and the adjacent part of Caernarvon, mapped as Cambrian by the Geological Survey of England, are probably of Pre-Cambrian age, a view which he mentions is supported by the opinions of Sedgwick and Phillips.

These rocks appear to him to be identical with the rocks of the Green Mountain series.

In the Highlands of Scotland there exists a great volume of fine-grained, thin-bedded mica-schists, with andalusite, staurolite, and cyanite, which are met with in Argyleshire, Aberdeenshire, Banffshire, and the Shetland Isles; these Dr. Hunt is convinced will be found to belong to a period anterior to the deposition of the Cambrian sediments, and will correspond with the newer gneissic series of the Appalachians.

Rocks regarded by Harkness as identical with these of the Scottish Highlands also occur in Donegal and Mayo.

From an examination of a large collection of the crystalline rocks of this area Dr. Hunt is enabled to assert the existence in the north-west of Ireland, of the second and third series of crystalline schists. He also observes that micaceous schists, with andalusite (chiastolite) of the type of the White Mountain series, occur on Skiddaw, in Cumberland.

He states his conviction that in the study of the crystalline schists, the persistence of certain mineral characters must be relied upon as a guide, and that the language used by Delesse in 1847 will be found susceptible of a wide application to crystalline strata—"Rocks of the same age have most generally the same chemical and mineralogical composition, and that reciprocally, rocks having the same chemical composition and the same minerals, associated in the same manner, are of the same age."

Turning now to the genesis of the crystalline schists whose geological relations he has just discussed, Dr. Hunt observes that the gneisses, mica-schists, and argillites of various geological periods do not differ very greatly in chemical constitution from modern mechanical sediments, and are now very generally regarded as resulting from a molecular re-arrangement of similar sediments formed in earlier times by the disintegration of previously existing rocks not very unlike them in composition.

The whole history of these rocks shows that their various alternating strata were deposited under conditions of sedimentation very like those of more recent times. In the Laurentian system, great limestone formations are interstratified with gneisses, quartzites, and even with conglomerates. All analogy, moreover, leads us to conclude that even at this early period life existed at the surface of the planet, and such has indeed proved to be the case by the discovery of the *Eozoön Canadense.* Great accumulations of iron-oxyd, beds of metallic sulphides and of graphite, exist in these ancient strata, and we know of no other agency, says Dr. Hunt, than that of organic matter, capable of generating these products.

REVIEWS.

I.—The Student's Manual of Geology. By J. Beete Jukes, M.A., F.R.S. Third Edition, re-cast, and in great part re-written. Edited by Archibald Geikie, F.R.S. 8vo. pp. 778. (Edinburgh: A. & C. Black, 1872.)

THE value of any Manual in relation to the branch of Natural Science of which it treats—and especially a Manual of Geology —depends to a very large extent upon the antecedents of its author, what has been his special line of research, and what have been his opportunities for study. If his training has been essentially geological, mineralogical, or palæontological, whether in the field and abroad, or only in the cabinet and at home, so shall we find a certain prominence of character given to one or other of these branches of inquiry, and broader or narrower views entertained.

Imbued as he was by Sedgwick, in his early days, with a love of the science of Geology, Prof. Jukes prosecuted his favourite study on all occasions, and the opportunities which he had by extended travel and by a large amount of detailed geological Survey-work, carried on both at home and abroad, gave him peculiar advantages as the writer of a geological manual, which we naturally find to be admirably adapted to the wants of the student. Since the publication of the first edition in 1857, Jukes's Manual has ranked foremost in this country as a geological hand-book; for while the works of other distinguished geologists, especially those of Sir Charles Lyell, have contributed more to further the progress of the science, and would, many of them, certainly, have attracted more readers, still no book was better adapted than Jukes's for a class-book for students taking up geology as a special subject, or as a guide (though a somewhat bulky one) for the traveller.

We need not go into the history of the present Manual, of which we have now the third edition, further than to remind our readers that it sprung, like several other scientific manuals, from an article in the *Encyclopædia Britannica*, which appeared under the heading "Mineralogical Science." Nine years having elapsed since the publication of the second edition, the progress of geology has necessitated great changes; indeed, Prof. Geikie remarks that so many changes have been made, that the present edition may in some respects be regarded as a new book. A large mass of additional material has been inserted; but by the use of smaller type, this has been effected without adding much to the bulk of the volume. This task, undertaken by the Editor at Mr. Jukes's special request, shortly before his death, could scarcely have fallen into better hands than those of Prof. Geikie, whose name is a sufficient guarantee for the manner in which it has been carried out.

The chapters (ii. and iii.) entitled "Lithology" and "Rock-forming Minerals" have been entirely re-written by Dr. Sullivan, and contain a vast amount of useful information; they seem, however, to go rather too deeply into the subject for the purpose of the student, making it very difficult and long, there being double the number of pages, and at least treble the amount of matter, introduced, as compared with the second edition. This coming first, is apt to discourage the beginner.

The Lithological portion, part of which had been revised by Mr. Jukes, has received much additional information from the Editor, and is thus rendered of greater value to the student. A novel feature in this edition is the separation of a part into "Dynamical Geology;" it includes chapters on the form and internal condition of the earth, the movements of upheaval and depression of the earth's crust, earthquakes, volcanos and volcanic action, and on underground changes effected upon rocks; these chapters are largely made up from the previous edition. Surface agencies, including denudation, also form part of the dynamical section, and these chapters are chiefly furnished by Mr. Geikie. It is interesting to observe that the purely geological portion of the volume, which in the previous edition occupied 372 pages, now fills 475 pages.

The palæontological portion appears with little alteration, and has been rather abbreviated by the omission of the parts relating to the "Life of the Period." It does not seem to have enjoyed the same amount of careful attention which has evidently been bestowed upon the other parts of the book. More names are needed in the lists of characteristic fossils, but these do not appear to have undergone adequate revision. For instance, only two new fossils have been added to the Cretaceous period, although many more have been recorded, especially from the Upper Greensand. *Notopocorystes* is now called *Palæocorystes; Ananchytes subglobosus* is now called *Holaster. Parasmilia* is not named in the list.

Prof. Huxley has furnished a new synopsis of the animal kingdom, which appears in the Appendix. The table of the vegetable kingdom was prepared by the late Dr. W. K. Harvey for Mr. Jukes.

In the re-casting of the Devonian chapter, a great deal of the matter from the second edition, relative to the Devonian question, has been omitted. The two pages of the Appendix can hardly be said to fairly represent this last labour of Mr. Jukes, upon which he had expended an immense amount of both time and patient investigation.

Very valuable additions to this volume are the numerous references to authorities where the student may find treated in detail the subjects which are discussed in it. Strange to say, only a single reference, however, is given to the works of the author, Prof. Jukes.

We sadly miss the excellent glossarial index, a most useful feature in the former edition of Jukes's Manual, as he attempted "to unite to some extent an index, a dictionary, and a gradus." In the present edition all explanations are left out, which can hardly be called an improvement. We would advise the student to provide himself with Page's Handbook of Geological Terms as a substitute, and he will not then feel the loss. We heartily commend this third edition of Jukes's Manual of Geology to all who are intending to become geological students.

II.—Geology of Oxford and the Valley of the Thames. By John Phillips, M.A., F.R.S., F.G.S., Professor of Geology in the University of Oxford, etc., etc., etc. 8vo. pp. 524. Illustrated by 17 Plates and 207 Woodcuts. (Oxford, 1871. Clarendon Press.)

THE volume before us—coming as it does from the pen of so able a geologist and so eloquent a writer and scholar as Professor Phillips—is interesting alike to the scientific man and the general reader.

Its contents may conveniently be considered under two general headings : Firstly, the Thames Valley, considered in its broad physical features and geographical relations to the rest of England, contributing, by its varied configuration, to render the neighbourhood of Oxford, and that of the Metropolis also, so pleasantly diversified. And, secondly, its Basement-beds, revealing the important fact that our river flows over the upturned edges of ancient strata rich in the relics of organic life, accumulated under more tropical conditions or in a much warmer climate than that at present existing.

For by consulting a geological map it will readily be seen that the strike of the Mesozoic strata being from the south-west to the north-east, and having a general inclination to the south-east, the beds which successively come to the surface are newer and newer in proportion as we travel in an easterly direction.

Rising as the Thames does, within a few miles of where the Severn is a navigable river, owing to the elevated position of its watershed, the Cotswold Hills, and flowing as it naturally must over the strike of less and less elevated beds towards the east, it exposes nearly all the Mesozoic strata, and, before it reaches the ocean, the chief part of the Tertiary deposits.

Replete as these strata are with the evidences of former life, and differing as they do in mineral character, as well as in their organic remains, they afford abundant illustrations of those mutations of the surface which the British area has so frequently undergone in the past, and reveal to us a series of faunas adapted to the successive physical changes it has witnessed.

It is to the elucidation of such subjects as these that the "Geology of Oxford and the Valley of the Thames" is devoted.

We may here remark that in dealing with the Oxford district, as a field of geological study, the author goes further westward, beyond the origin of the Thames valley proper, embracing within the scope of his work a review of the whole period of geological time from the oldest rocks of the Malvern range to the latest pre-historic alluviums.

Historical notices of the earlier writers who have contributed to the illustration of the geology of the Thames Valley, but more especially of the area around Oxford, occupies the first chapter.

The next 40 pages are occupied with a sketch of the "Hills and Vales," the Thames and its tributaries forming the main physical features of the district. The author gives a series of diagrams, designed to show the effect of a gradual submergence of the land, first to 250 feet below the present level, secondly to a depth of 500 feet, and thirdly to that of 1000 feet.

At the first, "the Thames Valley would be (must have been) a vast estuary, with a sea-lock up the Kennet Vale; straits between the chalk hills of Chiltern and Lambourn; locks right and left up the Thame and the Ock; straits near Abingdon; and again locks right and left up the Ray and up the Thames; narrower and far extended sea-channels up the Severn and the eastern rivers." (p. 44.)

At the second submergence we should only have "a series of islands branching out in a wide expanse of ocean; the Cotswolds broken up into many digitated masses; the Thames basin confluent with the Avon of Wilts and the Avon of Warwick; no limit to the sea on the eastward; still the straits of the chalk remain at Pangbourn; islets of the Oolite near Oxford; and other straits appear, especially on the Evenlode and the Cherwell, through which a communication is opened to the great midland sea which reaches to the hills of Lincolnshire, Derbyshire, and Shropshire. More than half the area of land in the Oxford district is now submerged." Thirdly, submerged "to 1000 feet and nothing of land remains but the higher peaks of the Malvern Hills, Cleeve near Cheltenham, and Broadway near Evesham. At intervals during the depression from 500 to 1000 feet, the straits of Evenlode and Cherwell might admit ice-rafts in abundance from the northern seas, and allow of violent wave-action on the parts of the land successively brought to the condition of sea-bed. Thus may the red pebbles of Warwickshire have been transported to the vale of the Thames, and many important effects of watery violence occasioned. The events here sketched have really occurred; the sea-line has been changed in the manner stated, in a comparatively late part of geological time, as it had often been changed before." . . . . "There is no evidence of this being a cataclysmic process, but much reason to treat it as a gradual subsidence and a gradual resurgence of the land." . . . . . "Both while rising and while falling, the water hammered against the shores and dredged along the channels; wasting the surface, reducing the heights, digging out the valleys, and spreading out detritus over submarine plains."

"Following continually the retiring sea, rivers often swept away the traces of its action, or covered them with fresh deposits. Atmospheric vicissitudes, rains and snows, heat and cold, disintegrated the rocks; carbonic acid aided in dissolving them; new phenomena replaced the older ones; new features were impressed on every hill and every hollow; and thus our land-surface, as we see it, exhibits in every part the modifications produced by what may be called the 'ordinary action' of daily causes, these being superimposed on broader and greater features generated by elevation and depression on a great scale, accompanied by powerful waves and strong currents of the sea." (p. 46.)

Fourteen chapters are devoted to the stratigraphical sequence of the rock-formations of the area. Each successive period is traced out mineralogically and palæontologically, and actual illustrative sections are referred to in every case, with complete lists as well as plates and woodcut illustrations of the fossils. Commencing with the Palæozoic rocks, Prof. Phillips shows that "the oldest stratified rocks of England, probably older than any in Wales, perhaps as old as any in Scotland, are found in the Malvern hills, within two hours of Oxford. These hills rise from the valley of the Severn, in a solitary ridge, to which there is really nothing very similar in the British Islands; the nearest analogues, by geological position and mineral character, being perhaps the felspathic rock-groups of the country about Charnwood Forest—very ancient rocks certainly, These Malvern hills meet us, on our journey from Oxford, like a wall. and differ in every way from all the strata which surround them." (p. 59.)

Thus we have in the Malvern ridge of very old rocks, gneiss, Granite, Syenite, Diorite. Besides these, which are all well-marked rocks, we have frequently greenstones, felspatho-hornblendic, or felspatho-augitic compounds, the felspar not being orthoclase, and not distinctly crystallized. Felstone, Quartz-rock, Serpentine, and mineral veins composed of Mica, Talc, Epidote, Graphite, Copper pyrites, and Copper carbonate, and sulphate of Baryta.

The second period is formed by the Cambrian rocks, represented by the Hollybush sandstone and the black shale yielding Trilobites of the Primordial type and other fossil-remains.

The Silurian, Devonian, Carboniferous, Permian, Triassic, Rhætic, and Liassic deposits are successively dealt with in greater or less detail, according to their development within the area treated of by the author.

But the great feature of the work, and that in which is displayed for the first time the results of Professor Phillips's latest and most important palæontological labours, is comprised in some three hundred illustrated pages (chaps. xi.–xiv.), embracing the author's "Bath Oolite Period." In it we are not only made acquainted with the hosts of the Invertebrata—corals, worms, mollusks, insects, crustaceans —met with in the Oolitic rocks, but with numerous fishes, some half-dozen of small mammalia (from Stonesfield), and that grand assemblage of reptilian remains for which Oxford has so long been famous, comprising, *Plesio-*, *Ichthyo-*, *Teleo-*, *Steneo-*, and *Dakosaurus;* the flying *Rhamphorhynchus*; several Cheloniæ; the great land-dwelling *Megalosaurus*, and that mightiest of ancient lizards, the giant *Cetiosaurus*, with the remains of which the name of Prof. Phillips will long be associated as its indefatigable investigator and restorer.

Space would fail us in which adequately to describe this ancient denizen of the Thames Valley. The earliest discovery of remains of *Cetiosaurus* dates back as far as 1825, to which subsequent additions from time to time were made by Dr. Buckland and others; but it was not until 1868 that the present discoveries of Prof. Phillips were commenced by the finding of a gigantic femur sixty-four inches in length, the precursor to the grand series of bones laid bare in 1870, comprising remains from almost every part of the skeleton. Some of the most striking of these, such as the vertebræ, ribs, scapulæ, humeri, ulnæ, pelvic bones, femora, tibia, etc., are drawn, one-tenth the size of the originals; and when we remember the hundreds of fragments from which these huge bones have been built up, we cannot but admire the skill and patience brought to bear upon the task by Professor Phillips and his assistant, Mr. Henry Caudel.

Taking the *lowest* of the various estimates of the size of this huge reptile (arrived at by measuring and comparing its bones with those of existing crocodiles and lizards), "we shall," says the author, "allow for a full-sized fossil animal the length of fifty feet," and so justify its name of the "whale-lizard." "Probably when 'standing at ease,' not less than ten feet in height, and of a bulk in proportion, this creature was unmatched in magnitude and physical strength by any of the largest inhabitants of the Mesozoic land or sea." (p. 293.)

Of the habits of *Cetiosaurus* we know but little; it was probably amphibian, "a marsh-loving or river-side animal, dwelling amidst filicinæ, cycadaceous and coniferous shrubs and trees full of insects and small mammalia." Its diet, if we may judge by the *single* tooth discovered, would indicate it to have been nourished by similar vegetable food to that on which the Wealden *Iguanodon* fed—thus adding another to the list of vegetarian lizards, to which the Liassic *Scelidosaurus* and the Cretaceous *Acanthopholis* also belong, and as contradistinguished from the predaceous *Megalosaurus*, of which, did space permit, we might give an extract from Prof. Phillips's graphic account, also accompanied by numerous figures.

In Chapter xiv., under "Change of the Forms of Life," and "Succession of Life-forms," we get some insight into the ideas on the origin of species existing in the author's 'many-sided mind.'

After illustrating, in a series of tables, the life-history of the Oolitic *Terebratulæ*, *Limæ*, *Trigoniæ*, and *Pholadomyæ*, Prof. Phillips remarks (p. 405): "Examples not less instructive, and all tending to the same conclusion, may be taken almost *ad libitum* from all the races of marine animals. In hundreds of instances we can trace backward in time the characteristic elements of generic structure to the earliest known type. In a small number of cases these lines of representative life, these probable genealogies, extend through all or nearly all the vast period which is known to us with certainty under the titles of Palæozoic, Mesozoic, and Cainozoic life; a period which can only be expressed by the inconceivable symbols of a million, ten, nay, a hundred millions of years. Yet, during all that immensity of time, through all the physical changes which have happened to inorganic nature, *Lingula* and *Rhynchonella* have existed with little real differences, as if to show the narrow limits within which modification by descent is restricted." And again (p. 406): "If the amount of change which can certainly be recognized in natural groups extend only to specific distinctions in the course of all assignable time, and yet genera have given birth to others unlike themselves, how vast must have been the pre-Cambrian periods, to have allowed of this change from some one supposed primary into the many definite genera which the Cambrian rocks contain! Many times one hundred millions of years would be required if the slow process now observable in nature be taken as the measure of effect: we have no trace of such periods, and perhaps astronomy and the mathematical theory of heat will not allow of such vast duration to the habitable condition of the earth." From these and other paragraphs we may conclude that Prof. Phillips is opposed to the theory of evolution, or at least that he derives no evidence in its favour from the course of his widely-extended and multifarious studies.

We regret that our limited space precludes our discussing critically the vast additions to palæozoology this work contains—a task in itself requiring far more space than we have already occupied; but independently of the original palæontological results so ably worked out and illustrated by means of the rich collections in the Oxford Museum—which he has for years been occupied in accumulating, and which must in themselves be of great interest to the student of palæontology—Professor Phillips's work contains in itself a concise sketch of Mesozoic Geology, which, in the form presented, cannot fail to prove of interest to all its readers.

III. Gaudeamus! Humorous Poems, translated from the German of Joseph Victor Scheffel and others. By Charles G. Leland. 16mo., pp. 154. (London, Trübner & Co., 1872.)

It may astound some of our readers to see in the pages of this Journal a notice of a book with such a title as the above; we must, therefore, at once explain that Scheffel's poems, as translated by Leland, are intended to form a part of every geologist's library, and the English edition being small, it can conveniently be put into every geologist's pocket or knapsack. Then, when the way proves long, and the load of rocks or fossils wearisome, he will find it is good to sit down on the first convenient seat by the wayside, and having taken out his pipe and his *Gaudeamus,* he will follow Mr. Leland's directions, and say to his companion if he have one—or to himself if he have none—"Let us be jolly."

Mr. Leland writes[1]—Joseph Victor Scheffel is at present the most popular poet in Germany, and "without being presented as such, these ballads, though complete in themselves, form in their connexion a droll history of the world and of humanity—advancing from the early outburst of Granite and Basalt, through the boulder of Gneiss to the Ichthyosaurus and Megatherium. Man then appears as a dweller in the Pre-historic Swiss Lake-dwelling on poles, where he bitterly bewails the misfortune of being a pioneer of civilization, and as one born before the invention of modern comforts."

> "*In stocks I would gladly grow wealthy.*
> *But exchange is not yet understood:*
> *A good glass of beer would be healthy,*
> *But never a drop has been brewed.*"—(p. 31.)

The early Phœnician is set forth in a droll song entitled "Old Assyrian-Jonah." p. 48.

There appear to be songs to suit all tastes; but two have especially delighted us, both by their originality and the excellence of their rhythm. One of these is entitled the "Guano Song," and describes

[1] Translator's Preface.

the Pre-historic colonies of sea-birds gradually building up the masses which form the Chincha Islands —

Ever pondering pious questions,
They labour right faithfully,
For blessed are their digestions,
And flowing like poetry.
For the birds are all 'Philosophen,'
To the principal precept inclined ;
If the body be properly open,
Then all will go well with the mind.

And the children pursue more enlightened
What their fathers in silence begun.
To a mountain it rises and whitened
By rays of a tropical sun.
In the rosiest light these sages
Look down at the future and say,
In the course of historical ages
We shall fill up the ocean some day. (p.24)

The other is named "Asphaltum," and describes the desolate region of the 'dead Dead Sea,' where a Dervish is keeping tryst 'with a maiden from Galilee.' But this must be read to be properly appreciated.

"The Tazzleworm" is another capital student's song; but how shall we choose among such an *embarras de riches?* Let us take "Granite."—

In his lair subterranean, grumbling
Old Granite said : 'One thing is sure,
That slopping and slippery tumbling
Up yonder, no more I'll endure.
So wearily wallows the water
His billows of brine o'er the land,
'Stead of prouder and fairer and better
All is turning to slime and to sand.

That would be nice limestony cover,
A sweet geological swash,
If the coat of the wide world all over
Were one sedimentary wash.
By and by 'twill be myth and no true thing
What were hills–what was high or was low.
The deuce take their drifting and smoothing ;
Hurrah ! for eruption I go !'

So he spoke, and to aid him, pro rata,
The brave-hearted Porphyry flew,
The weak-minded crystalline strata
He scornfully shattered in two.

With flashing and crashing and bellow,
As though the world's end were to dread,
Even Greywack, that decent old fellow,
In terror stood up on his head.

Also Stonecoal and Limestone and Trias
Fast vanished, internally mined.
Loud wailed in the Jura, the Lias.
That the wild fire had scorched him behind.
And Limestone, the marl-plot of chalkers,
Said later, in deep earnest chimes,
'Was there no one to stop, 'mong you talkers,
This wild revolution betimes ?'

But upwards through strata and fountains
Passed the conquering hero with heat,
Until from the sunniest mountains
He gazed on the world at his feet.
Then he shouted with yelling and singing,
'Hurrah ! 'Twas courageously done,
Even we can be doing and bringing
What it only needs pluck to be won.'

We cannot close this notice without thanking Mr. Leland for making us acquainted with this most amusing collection of ballads, and wishing it may be as well received as his former publications, "Hans Breitmann" and other ballads.[1] It may interest our readers to learn that "the geological songs owe their origin to a course of lectures on Geology which Pastor Schmezer delivered at the time.[2] Scheffel regularly attended these lectures of his friend, and the latter was certain to find as regularly on the following morning of his lecture a poetical résumé of it on his desk, in the form of a humorous poem."[3]

[1] Mr. Leland's list of works includes "Confucius and other Poems." "France, Alsace, and Lorraine." "Heine's Pictures of Travel," "Heine's Book of Songs," "Meister Karl's Sketch-Book." "The Poetry and Mystery of Dreams," "The Breitmann Ballads." This last-named series has attained the highest popularity both here and in America.

[2] In Heidelberg.

[3] Introductory Memoir of Joseph Victor Scheffel, by the Translator.

IV.—The Progress of Geological Research in Connection with the Geology of the Country around Liverpool.

By G. H. Morton, F.G.S., etc.

[Two Annual Addresses to the Liverpool Geological Society. Sessions XI. and XII. 1871.]

GEOLOGICAL literature is so vast and so diffused that all attempts to bring together and enumerate the bibliography of particular districts are most welcome. We not only want lists of papers on the geology of every British county and of particular districts, but also lists of writings on special Palæontological subjects, whether zoological or botanical; in fact, a sort of Ormerod's Index applied to all publications bearing on British geology is desirable.

Before writing a paper one has (at any rate one ought) to study the literature of the subject, in order to give due credit to those observers who have previously published communications on a similar topic. To find out what has been written on a particular subject is often a difficult task, therefore we are glad to see such papers as Mr. Morton's, wherein the bibliography of a district is given. In this paper Mr. Morton enumerates the geological writings in reference to the Carboniferous, Triassic, and Post-Pliocene strata of the country around Liverpool, giving also some criticisms upon them.

Mr. Whitaker has done a great deal of work in the same direction. We had occasion recently to notice his list of works on the Geology, etc., of Devonshire; and another list was, we believe, sent by him to the British Association at Edinburgh.

We may take this opportunity of mentioning to Lancashire geologists the title of a paper which we came across while looking up some communications on the Geology of Somersetshire, which does not appear in Mr. Morton's lists, a fact not to be wondered at considering the publication in which it occurs. It is this: "Remarks upon the inferior strata of the earth occurring in Lancashire, with some miscellaneous observations arising from the subject." By Dr. Campbell. With a coloured geological map of the county, by Dr. Wilkinson. In vol. xii. of "Letters and Papers on Agriculture, Planting, etc. Selected from the correspondence of the Bath and West of England Society,"[1] 1810, p. 85.

This is probably one of the earliest attempts to illustrate the geology of the county of Lancashire. H. B. W.

V.—Révue de Géologie, pour les années 1867 et 1868. Par MM. Delesse et Lapparent. (Paris, 1871.)

THE publication of the seventh volume of the Révue de Géologie was delayed in consequence of the troubles to which Paris was subjected during the late war. Like the previous volumes, it evinces the same care on the part of the editors in selecting and abstracting the most important papers and memoirs bearing on geology published during 1867—68, arranged under the sections of Physiographical, Li-

[1] The publication now carried on, as a second series, is the Journal of the Bath and West of England Agricultural Society.

thological, Historical, Geographical, and Dynamical Geology; besides which are some special papers sent expressly for the Review, such as M. Delbos' on the Department of the Haut-Rhin; MM. Mussey and Lacroix' on the Departments of the Ariége and Lot and Garonne; and a useful table of the classification of the rocks of Jura, with their mineral characters and characteristic fossils, by the late M. Ogérien; as well as some analyses of rocks and minerals made at the Normal School and School of Mines.—J. M.

REPORTS AND PROCEEDINGS.

Geological Society of London.—December 20th, 1871.—Joseph Prestwich, Esq., F.R.S., President, in the Chair.—The following communications were read:—1. A Letter from G. Milner Stephen, Esq., F.G.S., to the late Sir Roderick Murchison, dated Sydney, 5th October, 1871, announcing the discovery of a rich auriferous deposit on the banks of the river Bondé, on the N.E. coast of New Caledonia, and of a great deposit of Tin-ore in the district of New England, New South Wales. The gold in New Caledonia is found in drift, and there are indications of the near proximity of a quartz-reef. The Tin-ore in New South Wales is said to be in "pepitas, crystals, and beds of conglomerate; especially in Micaceous granite, more or less decomposed."

Discussion.—Mr. D. Forbes stated that in 1859 he had placed in his hands some specimens of granite from the district the discovery of tin in which was announced by Mr. Stephen, and that he found them to be perfectly identical with the stanniferous granites of Cornwall, Spain, Portugal, Bolivia, Peru, and Malacca, which he had also examined. These granites were all composed of white orthoclase felspar, colourless or black Muscovite mica, and quartz. He was not aware that tinstone (cassiterite or oxide of tin) occurred anywhere in rock of a different character. It was always accompanied by more or less native gold.

Mr. Pattison remarked that in many places where tin occurred it was not present in sufficient quantity to be remuneratively worked.

Mr. D. Forbes, in answer to a question from Prof. Ramsay, stated that, as far as could be ascertained, the age of the stanniferous granites mentioned by him must be between the end of the Silurian and the early part of the Carboniferous period.

Prof. Ramsay would carry them down to the close of the Carboniferous period, and would be contented to term them pre-Permian.

2. "Remarks on the Greenland Meteorites." By Prof. E. A. Nordenskjöld, For. Corr. G.S.

The author stated that the masses of meteoric iron brought from Greenland by the recent Swedish expedition seemed to have formed the principal masses of an enormous meteoric fall of Miocene date, extending over an area of some 200 miles. The iron appears to be free from silicates. Against its eruptive origin the author urges that when heated it evolves a great amount of gaseous matter, and that it contains imbedded particles of sulphide of iron, the mass itself being nearly free from sulphur. The masses are composed of meteoric nickeliferous cast and wrought iron, or of mixtures of the two; in the last case the Widmannstætten's figures are best developed. The author further noticed the various conditions in which the iron occurs; viz. 1, as meteorites; 2, filling cracks; 3, as brecciiform stones cemented with oxide and silicate of iron; and 4, in grains disseminated in the basalt.

Discussion.—Mr. Roberts protested against the evolution of gaseous matter being considered as a proof of meteoric origin.

Prof. Ramsay reiterated his previously expressed opinion, that the masses of iron might be of telluric origin.

3. "Further Remarks on the Relationship of the *Xiphosura* to the *Eurypterida* and to the *Trilobita*." By Henry Woodward, Esq., F.G.S.

In this paper the author described the recent investigations made by Dr. A. S. Packard, Dr. Anton Dohrn, and the Rev. Samuel Lockwood, upon the developmental history of the North American King-crab (*Limulus Polyphemus*), and discussed the conclusions as to the alliances of the Xiphosura and Eurypterida, and the general classification of the Arthropoda, to which the results of these investigations have led Dr. Dohrn and some other continental naturalists. According to this view, the Xiphosura and Eurypterida are more nearly related to certain Arachnida (the Scorpions, etc.) than to the Crustacea; and this opinion is further supported by the assertion of Dr. Dohrn, that in *Limulus* only one pair of organs (antennules) receives its nerves from the supraœsophageal ganglion, and that the nature of the underlip in *Limulus* differs from that prevailing among the Crustacea. Dr. Dohrn also recognizes the relationship of the Merostomata to the Trilobites, as shown especially by the development of *Limulus*, and considers that the three forms (*Limulida*, *Eurypterida*, and *Trilobita*) should be combined in one group under the name of *Gigantostraca*, proposed by Häckel, and placed beside the Crustacea. The author stated, on the authority of Prof. Owen, that *Limulus* really possesses two pairs of appendages which receive their nerves from the supraœsophageal ganglion; that, according to Dr. Packard, the young *Limulus* passes through a Nauplius-stage while in the egg; that no argument could be founded upon the lower lip, the condition of which varied extremely in the three groups proposed to be removed from the Crustacea; and he maintained that even from the ultra-Darwinian point of view taken by Dr. Dohrn, the adoption of his proposal would be fatal to the application of the hypothesis of evolution to the class Crustacea.

Discussion.—Prof. T. Rupert Jones remarked upon the interest attaching to the study of the Crustacea, and called attention to the absence of any indications of convergence in our present knowledge of the class. He thought that, in the present day, we must nevertheless look back to some point of convergence from which the varied forms known to us may have proceeded by evolution.

Prof. Macdonald remarked that difficulties must be expected to occur in classification. He believed that all Invertebrate animals were to be regarded as turned upon their backs, as compared with Vertebrata. The cephalic plate in *Limulus* he regarded as the equivalent of the palate-bone. The incisive palate was very distinct in the Crabs. The absence of one pair of antennæ did not appear to be any reason for removing *Limulus* from the Crustacea.

Dr. Murie considered that the contemplation of the multitude of young forms referred to by Mr. Woodward should serve as a warning to describers of species, and also as a check to generalizations as to the number of species occurring in various formations. He remarked that if we were at a point when the presence or absence of a single pair of nerves could be taken as distinguishing class from class, these classes must be regarded as very nearly allied. He thought that the doctrine of evolution was being pushed further than the known facts would warrant.

Mr. Woodward, in replying, drew attention to the series of diagrams of the embryo and larva of the recent *Limulus*, comparing them with *Limulus* of the Coal-measures, *Neolimulus* of the Silurian, and also with the larval stages of the Trilobites, discovered by Barrande. He pointed out the strong resemblance which the fossil forms offer to the early stages of the modern King-crab, and expressed his assent to the proposal of Dr. Dohrn to bring the Trilobita, if possible, nearer to the Merostomata. If, however, the Trilobites have true walking-legs instead of mouth-feet (gnathopodites) only, they would be more closely related to the Isopoda. He showed by a tabular view of the Arthropoda that the known range in time of the great classes is nearly the same, and therefore affords no argument for combining the Merostomata with the Arachnida; but, on the contrary, he considered that the Trilobita were, with the Entomostraca, the earliest representatives of the class Crustacea, and could not therefore be removed from that class.

Royal Geological Society of Ireland.—Wednesday, December 13th. William Ogilby, Esq., F.G.S., in the Chair.—William Hellier Baily, F.L.S., F.G.S. etc., read a paper, "Additional Notes on the Fossil Flora of Ireland." He first described a new fossil plant, collected by the Geological Survey of Ireland from the Carboniferous Limestone, at Whitestone Quarry, near Wexford, under the name of *Filicites plumiformis.* This fossil he alluded to as being of a very unusual character compared with those hitherto observed in the Coal-shales, or Carboniferous strata generally, bearing a considerable resemblance to some of the Cycadeæ, especially Palæozamia, a genus at present confined to Oolitic strata. The author observed that it approached most nearly in form to *Filicites vittarioides* (Brongn. Vég. Foss., pl. 137, fig. 1), from the Coal-formation of Richmond, Virginia.—The author then brought before the meeting the results of his examination of the collections made from the interesting fossil locality in the Upper Old Red Sandstone of Kiltorcan, county of Kilkenny, these fossils having excited considerable attention from Continental and American palæontologists. The large Fern originally named by the late Professor Edward Forbes *Cyclopteris Hibernicus,* he alluded to as being now referred by Dr. Schimper to his genus *Palæopteris,* who described it as differing from *Cyclopteris* in the arrangement of its leaflets, and from *Adiantites* (in which genus it was afterwards placed by Brongniart) in its mode of fructification. Two additional species of Fossil Ferns had been since described by the author from this locality, *Sphenopteris Hookeri* and *S. Humphresianum.* Another plant frequent at this place, having a fluted or ribbed stem, had been referred by him to *Sagenaria Veltheimiana.* Professor Schimper, however, to whom he had sent a series of specimens, considered it to be a distinct species, naming it *Knorria Bailyana,* he having had opportunities of comparing its fruit with that of *S. Veltheimiana,* from which it differed considerably. The author believed the plant named *Lepidodendron,* and afterwards *Cyclostigma minuta* by Dr. Haughton, to be the upper branches of *Knorria.* Drawings of this species were exhibited by him of the natural size, showing a root allied to *Stigmaria,* succeeded by a longitudinally ribbed stem like *Sigillaria,* the upper portion branching. Associated with it, cone-like bodies occur, composed of elongated scales, to which are appended long grass-like linear leaves, some of the detached scales showing large and very distinct sporules at their base; these were considered by him to be in all probability the fruit of this species.—The plants named *Cyclostigma* by Prof. Haughton, which are also abundant at this locality, the author believed to be quite a distinct genus from *Knorria*. He showed that the external characters and condition in which it was found offered no comparison with that species; there was no ribbing of the surface, which was marked by fine striæ, the rows of stigmæ being arranged at much wider distances. The author believed the plant named by Brongniart *Lepidodendron Griffithii*, to be a terminal branch of *Cyclostigma*. Of this genus Dr. Haughton had named three species; these the author proposed to restrict to one, *C. Kiltorkense*, Haughton.—In conclusion, the author brought forward facts to disprove the statement made by Mr. Carruthers in the discussion upon Dr. Heer's paper on the Bear Island Flora (as reported in the Journal of the Geological Society of London, vol. xxvii., p. 1, etc.), who had charged the Irish palæontologists with "misleading Professor Heer by their erroneous determination of the Kiltorcan *Lepidodendron*," and thus influencing his belief in the Carboniferous rather than the Devonian character of this deposit.—In addition to the Fossil Plants, the author enumerated the other associated Fossils at this rich locality: the Fish remains, including *Coccosteus*, *Pterichthys*, *Dendrodus*, and *Glyptolepis*, with new Crustacea named by him *Pterygotus Hibernicus*, *Eurypterus Kiltorkensis*, and *Proricaris McHenrici*; together with the only Molluscan shell named by Professor Forbes *Anodonta Jukesii;* all of these fossils indicative, in the author's opinion, of the fresh-water origin of this deposit.—Professor Haughton spoke as to the great value of the communication, and moved that the paper should be printed with fully illustrated plates, a resolution which was carried unanimously.

Professor Traquair's "Remarks on the Genus *Phaneropleuron*" was then read.

Geologists' Association, 5th January, 1872.—The Rev. T. Wiltshire, M.A., F.G.S., President, in the Chair.—"On the Overlapping of several Geological Formations on the North Wales Border," by D. C. Davies, of Oswestry. The author stated that the geological formations of the district ranged upwards from the Llandeilo to the New Red Sandstone. Attention was directed to the way in which nearly every one of these overlapped the one below, hiding in its course many of the beds, amounting in some cases to 1000 feet of strata, which at other points were exposed. The overlaps increase as a rule from north to south, except in that of the Bala and Caradoc beds by the Llandovery, which increases in an opposite direction. The author inferred that the conformability of strata at a given point did not necessarily prove the unbroken sequence or complete series of the beds at that point, and also that conformability between either two consecutive beds of the same formation or between those of two distinct formations was not to be expected to extend over a large area. Amongst other facts stated in this paper was the important one that Coal-seams occurred in Permian strata in the neighbourhood of Ifton.—The President remarked upon the enormous time required for the production of the phenomena described by Mr. Davies.—Prof. Morris explained the geological and physical features of the district, and spoke of the high value of the paper, "Report of the Proceedings of the Geological Section of the British Association at Edinburgh, 1871," by John Hopkinson, F.G.S., etc., one of the deputation from the Geologists' Association. In this communication the author succinctly stated the more important features of the opening address of the President, Prof. Geikie, and of the many papers read before Section C, at the meeting at Edinburgh last year, and gave interesting accounts of the two geological excursions under the direction of Prof. Geikie.—J. J. B. Ives, Esq., F.G.S., communicated the interesting fact of an extensive bed of peat occurring under gravel between Finchley and Whetstone.—Fossils from the Glacial deposits of Islington Cemetery were exhibited by Caleb Evans, F.G.S.—At the next ordinary meeting, 2nd February, a paper will be read by the Rev. T. G. Bonney, M.A., F.G.S., "On the Chloritic Marl Deposits of Cambridge."

CORRESPONDENCE.

THE RAISED BEACH ON PORTSDOWN HILL.

Sir,—Having been prevented by ill-health from attending the meetings of the Geological Society this winter, I missed the discussion of the President's paper on the above subject, read Dec. 6th, and crave your permission for a brief remark about it.

In my paper on the Weald, in the 27th volume of the Society's Journal, I endeavoured to show that the denudation of the Weald was brought about by a greater upcast of the western or Hampshire area over that of the eastern or Kentish area; the intensity of the forces producing this preponderating western upcast having given rise to the two rectilinear ridges of the Hogsback and Portsdown Hill. I also endeavoured to show, both by description and restoration maps, the way in which, as it appeared to me, the sea was pushed off eastwardly, and confined within an irregular trough, that, under the peculiar geographical conditions of the time, received the drainage of the Thames area in the reversed direction of its present flow, by means of which the Weald valley was denuded.

Although gravels occur at far higher elevations than that occupied by this raised beach, yet objections to the marine origin of such gravels—objections which cannot be settled one way or the other, by reason of the absence of organic remains—are always raised in opposition to the argument for the marine denudation of the south-east of England and Weald valley. Here, however, we have what seems to be admitted as a marine bed, at 300 feet elevation, on one of these two rectilinear ridges whose origin I thus have endeavoured to trace, and connect with the general marine denudation of the south-east. Three hundred feet would not only cover the major part of the Weald with the sea, but would also convert the south-east of England into an archipelago, in which the extent of the land-area would be intermediate between that shown in my restoration-map No. I., and that shown in No. II.; and it is to the period intermediate between these two restorations that I have assigned the upthrow of Portsdown Hill and the Hogsback.

The President connects the bed in question with the Brighton raised-beach; and if that connexion be well founded, we have this preponderance of the westerly upcast shown to the extent of nearly 300 feet in 40 miles, the Brighton beach being but little above the sea-level.

Searles V. Wood, jun.

CIRQUES AND TALUSES.

Sir,—The paper on Cirques and Taluses in your last number (p. 10), wherein my friend Mr. Fisher notices my theory of the formation of Cirques, seems to call for a few remarks on my part. I feel much indebted to him for the kind manner in which he has expressed his divergence of opinion from myself, and regret that, notwithstanding his able plea for glaciers, I must hold to my words.

He concludes that "a cirque, though not excavated by a glacier, is strictly a glacial phenomenon," while I have stated that, "the completeness of the cirque as a whole forbids us—unless we assign it entirely to glacial action—to suppose that it was more than slightly altered by this." To some extent the difference between us is more a question of words than anything else. I hold that atmospheric and stream action made the cirques; Mr. Fisher thinks that, by whatever agent they were made (probably as I have suggested), a glacier cleaned out the rubbish which must have accumulated in them prior to the Glacial epoch, and that, instead of saying "in not a few corries and cirques the transporting power (of stream) can *hardly* keep pace with the excavatory," I should have said can *not* keep pace. With regard to the former point, the glacier would most probably clear out the cirques, but I do not know that there is any evidence to show that they were formerly more choked up than they now are. As to the latter, I used the "word of doubtful signification" deliberately; because, although I think that not seldom the débris is on the whole accumulating, the increase is so slight as to be almost imperceptible; so that any unusually heavy storm may in an hour wash away the accumulation of a century. Débris strewn over iceworn slopes below the cliffs and screes masking the junction between these two (as in the case referred to) do not necessarily prove that the cirque is filling up; they only mark a stage in the quarry work of nature. The sawing of streamlets, aided by frost, etc., brings down the stone from the face of the cliff in fragments of various sizes; these, often broken smaller by their fall, lie on the slopes below, subjected to the same action of rain, heat, frost, until they are reduced to yet smaller fragments or even to fine dust, or are swept away by some swelling of the mountain burns. It must not be supposed that, when the stone is resting on the slope beneath a cliff, the work of destruction is over. I suspect that in many cases, could we watch it, we should find it proceeded with increased rapidity. A cube of stone in a cliff will at most only offer three or four faces to the corroding action of air and water, to the destructive influences of heat and cold; the same, when detached, will offer five or even six. As every mason knows, there are not a few building stones that must not be used for corners. I do not of course question Mr. Fisher's remark, "If the talus grows, the inevitable result must be that the vertical face will become in time a slope;" but I am not sure that the talus *does* grow; at any rate, I do not think that we can readily lay down a general rule; each case will have to be judged separately; the growth will depend upon the nature of the rock, the magnitude of the streams, the climate of the locality, and many other causes which will greatly complicate the question. Taluses may increase in one age, diminish in another; or at the same time be growing in one country, while dwindling in another. With regard to that particular cirque in Skye of which I spoke, I believe that a few able-bodied men could clear out in a short day's work all the débris that has accumulated since the Glacial epoch. It must not be forgotten, in the case of many rocks, the destruction of the talus will not be confined to the surface; the streams often more or less sink into it, and wherever the water makes its way, there disintegration will proceed. I believe therefore, as I have said, that a talus does not *necessarily* mark more than a stage in Nature's quarrying operation, and that she may be, and sometimes is, quite competent to remove all her 'spoil' without the intervention of a glacier. With regard to the mode of formation of cirques, I can only say that I have never seen one where there have not been many small convergent streams, and that I believe the two will be found as inseparable as cause and effect usually are. A quaquaversal dip would, no doubt, be favourable to the production of a cirque, but I have no reason to suspect its existence in most of those cases which I described in my communication to the Geological Society.

T. G. Bonney.

ON THE LIMESTONE AT CANNINGTON PARK,[1] NEAR BRIDGWATER.

Sir,—As some doubts have been entertained as to the date of the Limestone occurring at Cannington Park, it may be worth mentioning that I have lately had an opportunity of examining the corals that have been collected from that locality by the Earl of Cavan, by Mr. J. D. Pring, of 22, Hampton Park, near Bristol, and by the late Mr. William Baker, F.G.S., of Bridgwater; the specimens collected by the latter being now in the Taunton Museum.

They consist of the following Carboniferous genera and species:—

1. *Lithostrotion Martini.*
2. *Lithostrotion irregulare.*
3. *Lithostrotion aranea.*
4. *Clisiophyllum turbinatum.*
5. *Clisiophyllum, sp. ?*
6. *Syringopora ramulosa.*

[1] See Proceedings of Somersetshire Archæological and Nat. History Society. Vol. for 1850, p. 129; 1852, p. 125; 1854, p. 105.

Lithostrotion aranea I believe to be of very rare occurrence at Cannington Park. But one specimen as far as I am aware has been obtained from the locality, and that by Mr. Pring. This specimen, with the others collected by him, are now in the Museum of Practical Geology in Jermyn Street. I should expect *Cyathophyllum Murchisoni* to occur in this Limestone, though I have not as yet seen an example of this species among the Cannington fossils. There are some corals in Mr. Pring's collection from the same locality which would at first sight appear to be of Devonian type, but on account of their obscurity and bad preservation it is difficult to determine their nature. I have not observed them in the Mountain Limestone of any other district. The corals in the Cannington Limestone do not appear to have attained a large size.

The Limestone in parts is Oolitic in structure, and is identical in character with that developed in the neighbourhood of Bristol. It undoubtedly belongs to the Upper Carboniferous Limestone, and is probably of the same date as those portions of the massive limestone occurring in the Mendips, and in the neighbourhood of Bristol, of which *Lithostrotion Martini* is a characteristic coral.

Small opaque quartz crystals, with double terminations, presenting an Oolitic structure, occur in portions of the Cannington Limestone, of which there is a specimen in the Taunton Museum, with the crystals weathered on the surface, collected by Mr. Baker.

It is important to observe that there are some specimens in the Taunton Museum, from the collection of Mr. Baker, which I hardly believe are from Cannington Park, though labelled as such, and though some are specimens from the Mountain Limestone. One consists of a large polished slab of a Devonian astræiform coral of unusual size (*Cyathophyllum Boloniense*), and is palæontologically and lithologically distinct from the Cannington Limestone. The Limestone composing this specimen is of a white pearly colour, with a bluish-grey tinge, translucent, highly-crystalline, and impregnated with sulphuret of iron (iron pyrites). I believe Mr. Baker obtained it of Hurford, a stone-mason at Bridgwater, on whose authority he labelled it "Cannington Park." Judging from the quality and size of the specimen, I should think it must be from Devonshire.

Henbury, Bristol,
Jan. 1872.

S. G. Perceval.

THE GREENLAND METEORIC STONES.

Sir,—On the 30th of June, 1862, I sent a letter to the *Hampshire Chronicle,* entitled "Twenty Steps in the International Exhibition." It ended thus, in reference to a "so-called meteorite" which was exhibited. "All *evidence* that a meteorite ever fell on earth is unworthy of belief. The *argument* for it is this. Nickel, iron, etc., are not found similarly mingled in any other substance on *earth.* If they were they would not be an *other* substance, but the *same* substance. But does it follow from this that the substance comes from *heaven?* How many other substances must come from heaven by this reasoning?" In the Geological Magazine for October, 1864, page 191, are these words: "Colonel G. Greenwood has favoured us with a letter on the improbability of the existence of real meteoric stones." In your this month's number, page 571, Professor Ramsay takes my side.[1] He thinks that the Greenland (meteoric!) stones may be of terrestrial origin; "that, supposing the earth to have in part an elementary metallic core, eruptive igneous matter might occasionally bring native iron to the surface."

BROOKWOOD PARK, ALRESFORD. GEORGE GREENWOOD, Colonel.

MINERALOGY OF CORNWALL AND DEVON.

SIR,—In the very favourable review of my "Handbook to the Mineralogy of Cornwall and Devon," which appears in the Dec. number of the GEOLOGICAL MAGAZINE, your reviewer remarks that "Stenna Gwynn is given as a locality for Wavellite, while under Tavistockite it is correctly stated that this is the mineral, *as first noticed by Dana*, that really occurs there, and *not* Wavellite, for which it was formerly mistaken."

On this point I should wish to make two remarks. First, that I did not give Stenna Gwynn as a locality for Wavellite, but merely stated that "*it is said* to have occurred" there, which is perfectly true.

Second, the authority for Tavistockite is not Dana, but Mr. Michell, of Calewich, near Truro, who discovered what he calls "Soft Wavellite," but which appears to have been what is now called Tavistockite, more than fifty years ago, and mentioned it in a book published anonymously at Truro, in 1825 or 1828. J. H. COLLINS.

FALMOUTH, *Dec.* 26, 1871.

OBITUARY.—SAMUEL HUGHES, Civil Engineer, of Park Street, Westminster, was elected a Fellow of the Geol. Soc. of London in 1847, and died in October, 1870, at the age of 55. He early evinced a taste for natural sciences, and the most successful results of his more important undertakings in connexion with the supplying of water to towns was due to his knowledge and practical application of geology. He wrote the "Water Works" for Weale's Series, and throughout it he insists upon the necessity of possessing a familiar acquaintance with the stratigraphical relations of our rock groups. During the latter part of his life he rose to be amongst the first scientific gas engineers of the day, which was in great part due to those habits of careful observation and rational deduction which result from the study of physical phenomena. In this branch of engineering also he wrote the text-book for Weale's Series.

[1] Prof. Ramsay thought the Greenland (Meteoric) Iron *might be* of terrestrial origin; but he *did not* (like Col. Greenwood) deny the existence of real meteoric stones. If the Colonel will visit the British Museum any day, he may see a very large series of iron and stone meteorites, the circumstances attending the fall of many of which are well authenticated. As spectrum-analysis has revealed to us that many of the heavenly bodies are composed of like elements with our own planet, it need not surprise us to find that fragments of such bodies, falling on our earth, should be composed of the same materials.—EDIT. GEOL. MAG.

C. L. Griesbach. del et lith. Mintern Bros. imp.

Rostellaria. Pricei. *H. Woodw.* (Nat size.) Gray Chalk. Folkestone.

THE

GEOLOGICAL MAGAZINE.

No. XCIII.—MARCH, 1872.

ORIGINAL ARTICLES.

I.—On a new species of Rostellaria from the Gray Chalk, Folkestone.

By Henry Woodward, F.G.S., F.Z.S.,
Of the British Museum.

(PLATE III.)

THERE is perhaps no better collecting-ground in England for Lower Cretaceous Fossils than Folkestone, nor any which has been more industriously explored. The last fossil from this locality recorded in our Journal was in 1867 (Geol. Mag., Vol. IV., p. 65, Pl. V.), when Prof. Huxley described the remains of a new reptile from the Chalk-marl east of Copt Point, Folkestone, under the name of *Acanthopholis horridus*. In the same Journal will be found (at p. 67) an interesting notice by Mr. Robert Etheridge, F.R.S., Palæontologist to the Geological Survey of Great Britain, of the stratigraphical position of the Cretaceous series at this locality, from whence Mr. Griffiths, the intelligent collector, obtained these and the many other fossils with which the cabinets of the Rev. Thomas Wiltshire, M.A., F.G.S., Mr. J. Starkie Gardner, F.G.S., and those of so many other private collectors as well as of our public Museums are stored.

I am indebted to Mr. F. G. Hilton Price for the opportunity of calling attention to a new *Rostellaria* from the Gray Chalk of this locality, which he recently obtained during a geological excursion accompanied by Mr. Griffiths, whose services as guide are most valuable upon such occasions.

Those who, like myself, may have had occasion to consult the works in which are recorded the scanty remains of Mollusca from the Chalk-series in England will best be able to appreciate the value of such an addition as the fine fossil figured on Plate III. accompanying this notice. In Fitton's, Sowerby's, Dixon's, Woodward's, and Mantell's works, I can find no form with which to compare this interesting specimen; nor yet do I meet with it in the 'Paléontologie Française' of D'Orbigny, nor in the 'Palæontologia Indica,' with its fine series of Cretaceous Gasteropoda figured and described by Dr. Ferd. Stoliczka.

Geinitz, Reuss, Schloenbach, and many others have equally failed to aid me with information.

The only form approaching the subject figured on Plate III. in size and character is a shell called by Mr. Harry Seeley *Chemnitzia Woodwardii,* from the Chalk of Sussex, and preserved in the Brighton Museum. Of this and other specimens Mr. Seeley gives some notes and outline-sketches in the "Geologist," vol. vii., 1864, p. 89, pl. viii.; the figures, however, are too roughly executed to convey more than a very general notion of the specimens, and are, unfortunately, unaccompanied by references to the plate in the text.

Mr. Seeley has, however, obligingly supplied me with the requisite references, which I append for the convenience of those who may care to take the trouble to add them to the text of their copy of the "Geologist."

Chalk Gasteropoda recorded by Mr. H. G. Seeley, F.G.S., in the "Geologist," 1864, vol. vii., pp. 89–93, pl. viii., part of the collection of the Brighton Museum.

1. *Cerithium ornatissimum,* var., p. 89, pl. viii., figs. 7 & 8.
2. ——— *Gallicum,* D'Orb., var., p. 90, pl. viii., fig. 3.
3. *Pleurotoma amphiloga,* n.sp., var., p. 90, pl. viii., fig. 2.
4. *Fusus trachys,* n.sp., var., p. 91, pl. viii., fig. 13.
5. *Chemnitzia Woodwardii,* n.sp., p. 91, pl. viii., fig 1.
6. *Solarium ornatissimum,* n.sp., p. 91, pl. viii., figs. 15 & 16.
7. *Pteroceras,* representative of *Fittoni,* p. 91., pl. viii., fig. 4.
8. *Pleurotomaria Jukesii,* n.sp., p. 92, pl. viii., figs. 10 & 11.
9. *Trochus,* sp. ?, p. 92, pl. viii., figs. 5 & 6.
10. *Trochus* (near *T. Geinitzii,* Reuss), p. 92, pl. viii., fig. 9.
11. *Fusus* (?), p. 92, pl. viii., fig. 14.
12. *Fusus* (?), p. 93, pl. viii., fig. 12.
13. *Solarium Binghami,* Baily, p. 93, pl. viii., fig. 17.

Mr. Seeley's description of *Chemnitzia Woodwardii* is as follows:—

"Shell subcylindrical, two and a half times as high as wide, consisting of about 7 whorls, which regularly increase in size and are moderately convex. Each whorl is one and three quarter times as wide as high. The space where the whorls adjoin is concave, and the suture is indistinctly seen. There is no ornament, but a great number of fine and close spiral striæ. This and some other shells have quite an Oolitic aspect." (p. 91, op. cit.)

A comparison of Mr. Price's specimen with the above description and with Mr. Seeley's figure (op. cit. pl. viii. fig. 1) will suffice to preclude us from placing them together.

Whilst the absence of the mouth in *Chemnitzia Woodwardii,* Seeley, renders it impossible to determine its genus with certainty, its presence in Mr. Hilton Price's specimen clearly forbids its reference to *Chemnitzia.*

In *Chemnitzia* the shell is "slender, elongated, many-whorled; the whorls plaited; apex sinistral: aperture simple; ovate; peristome incomplete."[1] Upwards of 180 fossil species have been provisionally referred to this genus; many of them are of gigantic size as compared with the existing species, all of which are small.

To the genus *Pteroceras* D'Orbigny alone has referred nearly 100 species of fossil shells, ranging from the Lias to the Chalk; many of them are, however, more nearly related to *Aporrhaïs.* *Cerithium* is another genus which has nearly 500 fossil species, ranging from

[1] Woodward's Manual of Mollusca, p. 126.

the Trias to the Tertiaries; but I have been unable to refer the shell under consideration to any of these genera.

Our *dernier ressort* then appears to be in the genus *Rostellaria.*

There are more than 70 species of fossil shells referred to this genus, ranging from the Neocomian to the Tertiaries, although some of these may belong more correctly to the genus *Aporrhaïs.*

The shell in *Rostellaria* has "an elongated spire; the whorls are numerous, flat; the canals long, the posterior one running up the spire; outer lip more or less expanded, with only one sinus, and that close to the beak."[1]

The fossil on Plate III. agrees very fairly with the above diagnosis. The spire is elongated, the whorls are numerous (probably not fewer than fourteen, but about one inch of the apex of the spire is lost); the sutures are not depressed, and the whorls are flat (not tumid, as in *Chemnitzia Woodwardii*). The fine spiral striæ (with which the whorls are ornamented) are confined to a narrow band next the suture upon the upper border of each whorl, as is the case in the modern *Rostellaria curta* and other species. The last whorl is twice the breadth of the preceding whorl. The outer lip is expanded, nearly semicircular in form, and smooth-edged; the anterior canal nearly one-fourth the entire length of the shell (a small portion of its extremity is wanting); a slight ridge along the border of the penultimate whorl may possibly indicate the posterior canal, which in many species of *Rostellariæ* exhibits a well-marked ridge along one or more of the whorls—even to the apex in some species. Fine lines of growth are the only other ornamental markings upon the surface of the shell in addition to the spiral striæ along the sutural border of each whorl already referred to. The length of the last whorl, including the anterior canal, probably equalled the length of the entire spire when the termination of both the spire and canal were perfect. Length of actual specimen preserved 7¼ inches. Probable length when perfect 9 inches.

Believing, as I do, that this shell is really the representative of a new species of Cretaceous *Rostellaria,* I have ventured to name it *Rostellaria Pricei* in honour of its discoverer, in whose cabinet the original specimen is preserved.

II.—On the Method of Formation of the Permian Beds of South Yorkshire.

By A. H. Green, M.A., F.G.S.

PROFESSOR Ramsay in a recent paper[2] put forward the notion that the Magnesian Limestone and its associated beds of the north-east of England were formed, in part at least, by chemical precipitation in an inland sea. Given such a sea, without outlet, and with streams flowing into it holding in solution the necessary salts (bicarbonate of lime and sulphate of magnesia would answer the purpose), it is clear that by continued evaporation a state of

[1] Woodward's Manual of the Mollusca, p. 105.
[2] Quart. Journ. Geol. Soc. of London, vol. xxvii., p. 245.

saturation would at length be brought about, and precipitation would take place, and Dr. Sterry Hunt has shown that dolomite and gypsum would be the probable products.

Such a state of things would be by no means favourable to animal life; few creatures could exist at all under such circumstances, and the few that did manage to live on would show by their dwarfed and stunted forms how trying were the conditions against which they had struggled. Professor Ramsay pointed out that this was just the character of the Magnesian Limestone fauna, that the species were few and the individuals puny, and he showed how in this respect it agreed exactly with the fauna of recent inland seas, such as the Caspian and the sea of Aral.

The paper dealt with broad, general views, and did not pretend to enter into details. On reading again, however, the paper of Mr. Kirkby on the Permians of South Yorkshire,[1] the palæontological minutiæ, so admirably worked out therein, seemed to me to confirm in a remarkable way Prof. Ramsay's theory; and I think it is worth while to call attention to them, especially as I do not know that their bearing in this direction has been noticed before.

The Permian beds of South Yorkshire fall into the following subdivisions:—

6. Upper Marls and Sandstones with Gypsum.
5. Upper Limestone or Brotherton beds.
4. Middle Marls and Sandstones with Gypsum.
3. Small grained Dolomite.
2. Lower Limestone.
1. Quicksands.

Certain red beds below the quicksands, which were supposed by Prof. Sedgwick and other geologists to represent the Rothliegendes, are omitted here, because there is every reason to believe that they are nothing more than Carboniferous rocks stained by infiltration.[2]

No. 1. Pure unconsolidated sand, mostly finely grained, but occasionally containing small quartz pebbles; excessively current-bedded; very irregular in its occurrence. No sign of passage into the overlying limestone.

Loose sandy beds are found in places beneath the Lower Limestone, which are nothing more than the sandy residue of the limestone itself, the calcareous matter having been carried away by percolating water. Such beds, however, are totally distinct from the quicksands, and can be easily distinguished from them.

No. 2. Dolomitic limestone containing a large quantity of sand. Mr. Kirkby describes 31 species of fossils from this division. The mollusca are for the most part stunted, but some, notably *Axinus dubius*, are robust and abundant in individuals.

No. 3. Dolomite far purer and freer from mechanical admixture than the bed below: often crystalline or sub-crystalline. No fossils except a few traces in the lowest beds.

No. 5. Flaggy limestone, sparingly or not at all dolomitic, with thin way-boards and beds of red, purple, and green marls. Of the

[1] Quart. Journ. Geol. Soc. of London, vol. xvii., p. 287.

[2] See a paper by Mr. J. C. Ward, Quart. Journ. Geol. Soc., 1869, vol. xxv., p. 291.

31 species found in No. 2, which disappeared in No. 3, two reappear here, both excessively dwarfed. With the exception of some doubtful traces of plants, these are the only fossils known in this division.

Such are the facts, the meaning of them I take to be as follows :—

When the body of water in which these beds were deposited was shut off from the main ocean, some time would elapse before a state of saturation high enough to cause precipitation was reached, and during that time mechanical deposits alone would be formed. These are the Quicksands. One great characteristic of these beds is their irregularity, they occur in patches of various sizes, but are often absent altogether, and they thin out and disappear very rapidly, Their excessive cross-bedding shows too that they were formed by the action of currents. The most likely explanation of these facts seems to be that the Quicksands are the deltas of the streams which emptied themselves into the inland sea.

After a time the water became sufficiently saturated to cause dolomite to be thrown down to a moderate extent, and the chemical precipitate mixed with the sand brought down by the rivers gave rise to the sandy dolomite No. 2. The conditions, though not favourable, were not such as altogether to prevent the existence of animal life : hence fossils are found, but they are mostly dwarfed.

As the state of saturation increased precipitation went on more plentifully, so that the chemical gained the mastery over the mechanical element, and the purer dolomite No. 3 was produced. The animals could no longer hold their own, and were either killed off, or struggled on in nooks and corners, perhaps a little way up the rivers, where the state of the water was less trying to them.

Mechanical deposits predominated again during the deposition of No. 4, but the gypsum shows that chemical action was still at work.

During the formation of No. 5 the magnesian salts had so far disappeared, that the water became just habitable; and those hardy species, which had managed to live on, came back, showing, however, by their puny size how hard had been the struggle they had gone through. As far as we know, only two species survived, and it is worthy of note that one of these two is the lusty *Axinus dubius*, remarkable among the original fauna for its vigour and abundance.

One point still wants clearing up. Where did the supply of salts come from? The Permian epoch was one of great volcanic activity, and it was probably from mineral springs produced by volcanic action that the ingredients of the chemical parts of the deposits we have been considering were derived. Thus, though we do not find, as in Scotland and Germany, such convincing proofs of contemporaneous volcanic action as lavas and ash-beds, there is reason to believe that the Permian beds of South Yorkshire are indirectly of volcanic origin. To the same source we must look for the abundant supply of peroxide of iron which gives the colour to the red beds of the formation, and it is worthy of note that another formation, still more conspicuously red and also probably of lacustrine origin, the Old Red Sandstone, was formed during a time when volcanos were at work in Britain.

III.—On the Occurrence of the Genus *Endoceras* in Britain.

By H. Alleyne Nicholson, M.D., D.Sc., M.A., Ph.D., F.R.S.E.,
Professor of Natural History and Botany in University College, Toronto.

THE genus *Endoceras* was proposed by Hall (Pal. N. York, vol. i., p. 58) for a group of *Orthocerata*; having "a large siphuncle, mostly lateral or excentric, marked or ridged on the outer surface by the septa, which, from their oblique direction, give it the appearance of a tube with spiral lines. Within this siphuncle are one or more very elongated conical tubes, often one within the other to the number of four or five." The leading point, then, in the definition of *Endoceras* is the possession of a multiple siphuncle, composed of two or more concentric tubes placed one within the other, each tube having the form of an elongated cone. As to the existence of this peculiar structure, no doubt can be entertained; but very remarkable views have been put forward by Hall as to the true nature of these internal tubes. The tubes which are contained within the siphuncle are perfectly smooth and very thin, and they are believed, by the above-mentioned eminent palæontologist, to be receptacles within which the young shells were retained for a certain length of time. Upon this belief, they are termed by Hall "embryo-sheaths"; and it is asserted that they are found to contain young *Endocerata* in various stages of development, sometimes exhibiting septa and a siphuncle, and sometimes in the form of simple tubes, without either of these structures. As to the further development of these supposed young shells, Hall seems to have inclined to the view that the young *Endoceras* enlarged within the parent shell until the latter perished; but he seems to have also thought it possible that the young shells were expelled from the siphuncle of the parent-shell whilst still immature. It seems difficult to give any adequate explanation of the phenomena described by Hall, and it is at the same time very difficult to accept the views above stated. We know, however, so little of the functions of the siphuncle, especially in the extinct group of the *Orthoceratidæ*, that it is impossible to declare dogmatically that Hall's explanation of the phenomena may not be correct. Other observers, however, regard the supposed young *Orthocerata*, within the so-called "embryo-sheath," as having fallen accidentally into the cavity of the siphuncle, after the death of the animal; whilst the embryo-sheath is looked upon as the cast of the internal cavity of the siphuncle. Others, again, regard the embryo-sheaths as being of the nature of funnel-shaped diaphragms placed one within the other within the cavity of the siphuncle. This latter view, however, can hardly be correct, since the embryo-tube is described as not being connected with the walls of the siphuncle, whilst it commonly occurs detached from the shell to which it belongs. The former view, also, must be rejected, since it could at best but apply to cases in which only one "embryo-tube" was present.

Several species of *Endoceras* have been described by Hall from the Black River and Trenton Limestones, and some of them attained gigantic dimensions. No species of this genus, so far as I am aware, has ever been noted as occurring in Britain; and my object in the present communication is to describe a British specimen of *Endoceras proteiforme*, Hall, of which an accurate drawing is given below, together with a magnified portion of the surface.

The specimen in question was discovered by me in the Graptolitic Mudstones of the Coniston Series of the North of England, and it is one of the few fossils, beyond Graptolites, which have hitherto been detected in this formation. It consists of a much compressed and flattened tube, about two inches and a half in length, and seven-tenths of an inch in breadth. That the walls of this tube were

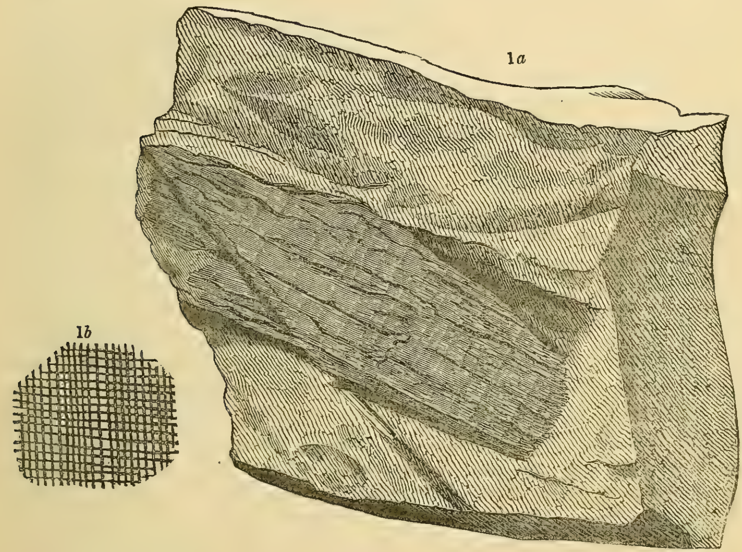


Fig. 1*a*. *Endoceras proteiforme*, Hall. Coniston Series.—Skelgill Beck, near Ambleside.
1*b*. A small part magnified.

extremely thin is shown by the fact that the surface of the fossil is thrown into longitudinal folds or corrugations, which are obviously due to compression. No traces of a siphuncle or of septa can be made out. The entire surface of the shell, however, is covered by a cancellated network of very delicate transverse and longitudinal striæ, giving it an exceedingly well-marked appearance, and arranged in a very characteristic manner. The transverse striæ are about one hundred and twenty-five to one hundred and fifty in the space of an inch, and are decidedly more conspicuous than the longitudinal striæ. Not only is this the case, but they are arranged in fasciæ, or bands, of three or four approximated striæ, separated by somewhat wider interspaces. Where the substance of the shell is preserved, the transverse striæ, as above said, are much better marked than the longitudinal striæ, and the latter can only be detected by the use of a lens. In places, however, where the fossil has been decorticated, the longitudinal striæ are nearly or quite as well marked as the transverse ones. The longitudinal striæ are about eighty in the space of an inch, and are, therefore, not so closely approximated as are the transverse striæ. The result of this is, that the spaces included between the two sets of striæ are oblong in the parts occupied by the crowded fasciæ of transverse striæ, whilst they become nearly square in the interspaces between these fasciæ. Independently of the transverse striæ, the surface of the shell is marked by numerous slightly elevated transverse ridges or annulations, which are placed at no constant distance from one another, and which do not, therefore, mark the position of septa in the shell.

In the absence of any traces of septa or of a siphuncle, it may seem somewhat hazardous to refer our fossil to *Endoceras*; but the nature of the surface-marking is so characteristic, that I feel no hesitation in determining it to be a young specimen of *Endoceras proteiforme*, Hall. The following is the description given by Hall of this species (Pal. N.Y., vol. i., p. 208):—

"General form cylindrico-conical, more or less elongated, often compressed, tapering somewhat unequally in different specimens; young specimens terminating in an extremely acute point; surface marked with distinct transverse striæ, which usually appear like narrow sub-imbricating bands, with one edge well defined and more elevated than the other, more or less distinctly striated longitudinally; striæ varying from extreme tenuity to distinct elevated thread-like lines; section circular; septa distant from one-fifth to one-fourth the diameter; siphuncle excentric or submarginal." The siphuncle in old specimens usually contains "a smooth cylindrico-conical embryo-tube or sheath," within which are young shells, which may or may not possess septa and a siphuncle, but which are distinguished by their surface-marking from the perfectly smooth enveloping tube.

Hall distinguishes three chief varieties of this species.

1. *E. proteiforme*, var. *tenuistriatum*, having the transverse striæ much more conspicuous than the longitudinal striæ, and often arranged in fasciæ.

2. *E. proteiforme*, var. *tenuitextum*, very similar to the preceding, but having the striæ of both sets more nearly alike and equal, being also "more distinctly elevated and thread-like."

3. *E. proteiforme*, var. *lineolatum*, having numerous delicate transverse striæ, arranged in fasciæ, but having no longitudinal striæ in the majority of instances.

The first two of these varieties hardly appear to be distinct, but upon the whole our specimen agrees most closely with the second of these. I regard it, therefore, as being a young form of *Endoceras proteiforme*, var. *tenuitextum*, Hall. Its locality is Skelgill Beck, near Ambleside, in the black Graptolitic Mudstones of the Coniston Series, immediately above the Coniston Limestone; and it is, therefore, of later age than the American examples of the species.

IV.—On Changes of Climate during the Glacial Epoch.

By James Geikie, F.R.S.E.
District Surveyor of the Geological Survey of Scotland.

Fourth Paper.

(*Continued from the February Number, p.* 69.)

In my last communication to the Magazine I made an attempt to correlate the Scottish Glacial deposits with the equivalent accumulations in Switzerland, Northern Europe, and North America, my purpose being to show that the same order of succession holds good in all those regions where the "Drifts" have been examined, and that in each case there is no proof whatever of any warm period having intervened since the deposition of the clays with Arctic shells and the decrease and disappearance of local glaciers. In the present and a subsequent paper I propose to treat of the superficial deposits of Ireland and England, more especially those of the latter country. It is with some diffidence that I approach this discussion, because I feel that in venturing to dissent, as I must do, from opinions somewhat generally received, I lay myself open to a charge of presumption. Yet it is just possible that one working in a country where the drift-deposits are neither very complex nor confused, and where the succession of events can be made out with tolerable certainty, may be able to let in some light upon the obscurity which it cannot be denied still clouds the history of the later geological changes in England. At all events it can do no harm to make the attempt.

So long as the geologist confines his attention to the mountainous districts of England, the sequence of the glacial deposits appears to be sufficiently clear. The lowest member of the series consists of a stony clay, above which, in some districts, come sheets and mounds of sand and gravel and erratics, while in certain valleys there occur heaps of loose moraine matter. Prof. Ramsay long ago interpreted the order of events for Wales thus: a period of vast glaciers, followed by one of great submergence, and this again succeeded in time by re-elevation and a second period of glaciers. But when the geologist continues his researches into the low grounds that sweep outwards from the base of the mountains a number of perplexing details come in to worry him. He finds not one stony clay only but several with intervening stratified deposits; and in his endeavours to correlate these, bed for bed, with other glacial accumulations, many difficulties arise. The day is yet distant when we can hope to see this hard task of correlation accomplished; and I certainly do not feel myself qualified to decide on a minute or detailed classification of the English drifts. All I mean to attempt is to point out in a general way what appear to me to be the equivalents of those divisions under which I have grouped the Scottish deposits. If the reader will take the trouble to refer to my last paper in the Magazine, he will observe that, in the several tables of Scottish and foreign glacial deposits, a series of marine beds (3) occurs after the Scottish (1) "Till, boulder-earth and clay," and (2) "moraine rubbish," and likewise after the Scandinavian (1) "stony clay, etc.," and the American (1) "unmodified drift," and (2) "moraines." These marine beds (*i.e.*, kames, eskers, and ösar) invariably occupy this position, and as they do so over such a vast extent of land in the northern hemisphere, they come to form a kind of datum line. If similar deposits occur in England, and if it can be shown that those are clearly of more recent date than certain other glacial accumulations, then these last must necessarily be to some extent the equivalents of the Scottish Till and associated beds. It is in the highest degree unlikely that the Glacial epoch in England differed materially from the same epoch elsewhere; yet the conditions under which the glacial and interglacial accumulations were laid down may have departed considerably from those that obtained in higher latitudes and in mountainous regions. We should naturally expect that the districts least exposed to the intensity of glacial action will contain more varied and more abundant series of deposits than those areas which have been subjected to a greater degree of glaciation. If, even in Scotland and North America, interglacial beds occur in the Till and "unmodified drift," surely in the low-lying districts of England these should be much better developed. And such, indeed, is the case. Both in the east and north-west maritime regions of England there occur beds of sand, gravel, etc., included between glacial deposits, just as in Scotland sand, clay, and gravel are overlain and underlain by till. The English stony clays are partly ground moraines and partly also deposits from floating ice; while others would appear to have been thrown down at or near where glaciers terminated in the sea, and hence resemble in origin the boulder-earth or clay of certain maritime districts of Scotland.

Some years ago Professor Hull showed that in Lancashire there are two Boulder-clays, separated by an intervening series of sand-beds. My colleague, Mr. De Rance, has since pointed out that underneath the lower of these Boulder-clays there occurs a deposit of Till answering in all respects to the Scottish Till, and being in Mr. De Rance's opinion a product of land-ice.[1] The overlying Boulder-clays he thinks are clearly of marine origin, that is to say, they have been deposited upon a sea-bottom. He writes to me also that the "Upper Boulder-clay" is covered by esker-drift. This being so, it would follow that the Lancashire Till and Lower and Upper Boulder-clays, with their intervening deposits of sand, are the equivalents of the Scottish Till and interglacial beds. There is nothing absurd in supposing that while some portion of the Till was being formed in Scotland, marine Boulder-clay was accumulating here and there in England. Yet the descriptions given of the Upper and Lower Boulder-clays of the north of England tally better with the character of the Scottish Boulder-earth and clay than with that of the Till; and the Lancashire beds may therefore represent those

[1] Mr. Hull was the first (1863) to point out clearly the threefold division of the drift of Lancashire into Upper and Lower Boulder-clay with the intervening Middle Sands (see his Memoir, Mem. Lit. and Phil. Soc. of Manch. 1865, p. 449). Mr. Binney had, however, previously mentioned the existence of sand-beds in the Boulder-clay, but these beds he believed to be of inconstant occurrence.

later stages of the Glacial epoch which preceded the era of great submergence and the accumulation of the kames and esker-drift. But the stony clay or till which is described by Mr. De Rance as underlying the Lower Boulder-clay, represents in all probability the Scottish Till.[1]

I think, therefore, it is hardly possible that the Middle Sand series of the north of England can be the equivalent of the Scottish kames. The kames are found, over and over again, to rest upon, and to be made up out of the denuded "boulder-earth and clay," which is the youngest stony clay in Scotland. It is true, indeed, that the later brick-clays occasionally contain a few stones, but no one on that account would think of calling them Boulder-clay. Thus even apart from the fact, mentioned by Mr. De Rance, that his Upper Boulder-clay underlies in some places true esker-drift, the evidence, I think, is yet sufficiently strong to show that the Middle Sands of the north-west of England cannot be the equivalents of the Scottish Kames.

Messrs. S. V. Wood and Harmer, in a series of interesting papers, have clearly pointed out a certain succession of boulder-clays and intercalated beds in the eastern maritime districts of England. Mr. Wood, if I follow him rightly, seems inclined to the opinion that his "great chalky boulder-clay" may be the English equivalent of the Scottish Till, the older glacial deposits of England not being represented in Scotland. But the Scottish Till, as I have shown, is not merely one single bed of stony clay; in places sheltered from the grind of the old glaciers, it exhibits several intercalated deposits of gravel, sand, mud, and clay, which, along with the separating Till, may very likely represent, to some extent, the middle and lower glacial groups described by Mr. Wood. The series in East Anglia is much better developed, simply, I believe, because that part of Britain has not been subjected to the same degree of glaciation as Scotland. It appears to me highly probable, therefore, that the whole series of Boulder-clays and intercalated sand and gravel beds of the east of England, up to and including the "purple boulder-clay of Yorkshire," are represented (inadequately, no doubt) by the Scottish Till, boulder-earth and clay, and the subjacent and intercalated silt, sand, clay, and gravel; and that the changes of climate which are indicated by the succession of the English drifts referred to, took place before the great submergence which ushered in the period of kames and that of erratics. This conclusion harmonizes with the results obtained by Mr. Wood in co-operation with Rev. J. L. Rome and Mr. F. W. Harmer. These geologists distinctly place the "great denudation and principal unconformity" after the deposition of the purple clay of Yorkshire. Thus, in East Anglia, marine gravels rest upon the denuded glacial deposits, and form a sharp line of demarcation between the accumulation of Boulder-clay and the formation of the later drifts, a succession which is precisely the same as in Scotland.

[1] Much of the "pinel" described by Mr. Mackintosh is also in all likelihood the same kind of deposit as the Scottish Till.

To what extent England was submerged during the interglacial periods does not at present appear. I cannot agree with those geologists who hold that the Moel Tryfan beds were deposited during the same period of submergence as the "Middle Sand" series of the north-west of England; and it may also be strongly doubted whether the Macclesfield deposits should be referred to this horizon. It may quite well be that the Middle Sand at Blackpool contains the same fossils as the high-level drift at Macclesfield, but it does not therefore follow that the beds at these places were thrown down during the same period. If it can be shown that several oscillations of climate characterized the Glacial epoch, then it must be admitted that the same species might appear and disappear, and appear again, according as the conditions were favourable or unfavourable to their existence in our seas. Similarity of fossils, therefore, cannot be taken exclusively as proof of contemporaneity. The "Middle Sands" of Lancashire and Cheshire tail out against the gradually rising ground at a height considerably below that attained by the Moel Tryfan and Macclesfield beds, and this of itself is good evidence against the contemporaneity of these latter with the Middle Sands. I agree, therefore, with Mr. Searles V. Wood, who appears inclined to relegate the Moel Tryfan and Macclesfield deposits to the period of great submergence (the kame series of Scotland). If a submergence to the extent of 1400 feet or more ever took place in Scotland during the deposition of the boulder-earth and clay (which are probably the equivalents of the Lancashire and Cheshire boulder-clays), it could hardly fail to have left some traces behind it. But there is no evidence of any such great interglacial depression having occurred at any period previous to the accumulation of the kames and high-level beaches. Professor Ramsay, it will be remembered, many years ago expressed his opinion that the beds at Moel Tryfan, from which Mr. Trimmer and he obtained shells, were laid down during the excessive subsidence that followed on the close of the period of vast glaciers, and preceded the era of small local glaciers. In short, the beds referred to appear to come into the same place in the series as the high-level beaches or shelves of Scotland, which are clearly of later age than all the boulder-clays.

The kames and erratics of Scotland are also represented in England by esker-drift and large ice-floated blocks and boulders. Over wide districts occur sporadic mounds and interrupted sheets, patches, and cappings of sand and gravel, with boulders, which geologists generally agree in considering to be of later date than the till, boulder-clay, and associated beds of sand, gravel, etc., in the northern and eastern districts of England. It is uncertain, however, whether the representatives of the Scottish clays with Arctic shells have yet been detected. The occurrence of so many marine clays belonging to different periods of the Glacial epoch, makes it difficult to determine this point, for, like Mr. Wood, I am not disposed to place much reliance on fossil evidence taken by itself. It is highly probable, however, that the Nar Clay and the Hessle Clay may occupy, as Mr. Wood has suggested, the same general horizon as the shelly Clays of Scotland. It is quite certain, at all events, that these latter, apart altogether from palæontological considerations, cannot possibly represent any part of the middle or lower glacial series of East Anglia.

The latest glacial deposits in England are the valley moraines of Wales and the north. When I say the *latest*, I do not mean to assert that any hard and fast line can be drawn between them and the esker-drift and erratics. Glaciers no doubt existed in our upland valleys during the dispersion of erratics, but they lingered on after the re-elevation of the land.

Throwing the general results now obtained into a tabular form, the succession, it will be seen, closely agrees with that of the Scottish drifts. I begin with the lower beds.

Glacial Deposits of North-west of England.	Glacial Deposits of East Anglia.[3]
1. Till; Lower and Upper Boulder-clay with Middle Sands.[1]	1. Lower, Middle, and Upper Glacial Groups.
2. (Not recognized).[2]	2. Wanting.
3. Esker Drift.	3. Marine Gravels.
4. Erratics.	4. Hessle Gravel, Nar beds, Hessle Clay.
5. Valley Moraines.	5. Wanting.

In Ireland, a tough stony clay, similar in all respects to the Scottish Till, has long been recognized, and underneath it, in some places, a "pre-glacial drift" is found, which occasionally contains the remains of trees, etc.[4]

A few years ago, Professor Harkness showed[5] that in County Wexford shelly sands occur below an "upper Boulder-clay," and these sands he took to be the same as certain other sands in the east of Ireland, which are seen to rest upon a "lower Boulder-clay." Great caution, however, is requisite in correlating glacial beds. It would appear that in the esker-drift of Ireland, which, like the Scottish kame-drift, is of later date than all the Till and Boulder-clay deposits, there occurs a similar assemblage of marine shells as that which characterizes the "Manure Gravels," with their cap of Boulder-clay.[6] In the absence of such an overlying Boulder-clay,

[1] It may be as well to remark that I offer no opinion as to the contemporaneity or non-contemporaneity of the Lancashire Middle Sands, and the Middle Glacial group of Mr. Wood. The balance of evidence appears to be against the synchronism of these deposits, but the question will, no doubt, be settled by-and-by—the zeal with which the deposits are being overhauled by Mr. Wood and his confreres in East Anglia, and by Mr. De Rance, Mr. Mackintosh, and others in the North of England, leaves one in no doubt about this. All I hold is that the beds grouped under No. 1 were laid down during the same great epoch, and are thus the equivalents of the Scottish Till and interglacial beds.

[2] It is possible, however, that some portion of the deposits in group 5 may belong to this period.

[3] I follow, of course, the sequence given by Mr. Wood. See Geol. Mag., Vol. VII., p. 18.

[4] See Notes on some of the Drift in Ireland by G. H. Kinahan. Dublin Quart. Journal of Science, vol. vi., p. 249. I am indebted to Mr. Kinahan for some MS. notes on the Irish drift.

[5] Geol. Mag., Vol. VI., p. 542.

[6] See Mr. Kinahan's paper, loc. cit. Possibly, however, some of the deposits referred to by Mr. Kinahan may belong to the "Middle Sand series."

therefore, it would be hazardous to place in the "Middle Sand series" any deposits of sand and gravel that happened to contain shells like those of the "Manure Gravels." Quite recently, Professor Hull recognized in the beds described by Professor Harkness the precise equivalents of the Middle Sands of Lancashire,[1] and gave a section showing the sand beds intercalated between an "upper" and "lower Boulder-clay."[2] I think, therefore, that the "upper and lower Boulder-clay" and intercalated shelly sands of Ireland are almost certainly the equivalents of the Scottish Till, Boulder-earth and clay, and interglacial deposits.

The deposition of the "Boulder-clays" of Ireland was followed, after an interval, by a period of submergence, during which the esker-drift was accumulated. From the presence in this drift of marine shells similar to those now living in British seas, it is quite plain that the climate during this period was temperate. But after the land had been submerged to a considerable depth[3] a great dispersion of erratics took place, clearly showing that the temperate conditions gave place to an Arctic climate. No shelly clays similar to those of the Clyde have yet been detected in Ireland; but the mountain valleys, like those of Scotland, Wales, and England, abound with traces of local glaciers.

I need not refer more fully to the details of the Irish Drift. The researches of my colleagues on the Geological Survey, and of many other observers, clearly show that the general succession of the glacial deposits in Ireland exactly coincides with that which obtains in Scotland.

For purposes of comparison I tabulate the Irish deposits, beginning as before with the lower beds.

Glacial Deposits of Ireland.

1. Till; Boulder-clays with intercalated beds.
2. ? (Not recognized.)[4]
3. Esker drift.
4. Erratics.
5. Valley moraines.

Thus wherever the Glacial deposits are examined, whether in Europe or America, they appear to give evidence of the same general sequence:

1st. A lengthened succession of periods of alternate glacial and

[1] Geol. Mag., Vol. VIII., p. 294.

[2] But for various reasons I am not prepared to agree with my colleague's suggestion that the "Limestone Gravel" of Ireland represents this Middle Sand group, or was ever covered by Boulder-clay. I believe that the Middle Sand series of Ireland ("Manure Gravels") will be found, as they are traced inland, to thin out against the gradually rising ground. It is so with the marine interglacial beds of the maritime districts of Scotland; and in all likelihood with those of the north-west of England also. The erratics resting upon the gravel ridges exactly tally with those occupying a similar position in Scotland, Northern Europe, and North America.

[3] Mr. Kinahan mentions the occurrence of marine terraces on Slieve Aughta at a height of 1200 feet. The Rev. Mr. W. Close also refers to shelly sands at a similar height on Three Rock Mountain.

[4] Mr. Kinahan describes a "rocky moraine drift" which, in part at least, may be the representative of the Scottish "moraine rubbish" mentioned in my last communication to the Magazine.

temperate conditions; the periods becoming less intensely contrasted towards the close.[1] This was the time of great continental ice-sheets, but in the later glacial periods of the same cycle the ice-sheets were less extensive. Oscillations of the relative level of land and sea took place, but to what extent is not known.[2]

2nd. A period of unknown duration, when the ice-sheets withdrew from all the low grounds, leaving behind them piles of rubbish. Climate becoming temperate.

3rd. A period of subsidence, during which the *moraines profondes* and terminal moraines were much denuded and their remains heaped up into mounds and ridges by the action of the sea. Climate temperate.

4th. A period of emergence, characterized throughout by arctic conditions; much floating-ice dispersing erratics over the submerged land; accumulation of clays with arctic mollusca; pauses in the upward movement marked by "raised beaches."

5th. A period of local glaciers in Great Britain and Ireland; continued elevation of land; continental condition of our island followed by partial submergence and re-elevation. Climate becoming gradually ameliorated.

Having now considered the glacial and interglacial deposits, I propose to take up some of those difficult problems which are suggested by the phenomena of the cave deposits and older river gravels of England. It will be seen in the sequel that the facts already adduced bear strongly upon this subject; indeed, without a clear conception of the succession of events revealed by our glacial deposits, it appears to me that we run some risk of getting into confusion when we seek te decipher the history of post-glacial accumulations.

V.—The Post-Glacial Geology and Physiography of West Lancashire and the Mersey Estuary.

By T. Mellard Reade, C.E.,
Associate of the Institution of Civil Engineers.

My attention having been directed, during the construction of the Main Outfall Sewer at Birkdale, to the Post-Glacial deposits underlying the great plain between Waterloo and Crossens, and having, through the execution of numerous other works in the district, peculiar advantages for prosecuting investigations in Post-Glacial Geology, I am induced to lay before your readers several interesting facts, and also, as I venture to think, some important deductions therefrom.

With the exception of the superficial sands and gravels and river

[1] The evidence derived from the Glacial deposits of East Anglia would make it appear that at the beginning of the cycle the arctic and temperate periods were also less strongly contrasted than they subsequently became.

[2] I have stated in the text my belief that the Macclesfield beds and those of Moel Tryfan ought to be referred to the period of great submergence, during which the kame series or esker drift was accumulated; they are in all probability the equivalents of the high-level shelves of drift met with in Ireland and Scotland, and likewise in North America.

valley deposits, described by Binney, Trimmer, and others, the great mass of Post-Glacial deposits of Lancashire and Cheshire lie on the margin of the sea-coasts, and of the rivers Mersey, Dee, and Ribble, and follow with remarkable regularity the 25-ft. contour line below which the bulk of them lie.

The Lancashire deposits between Waterloo and the river Douglas have a coast-line of about 24 miles long, are 4 miles wide at Formby, measuring from high-water mark, and run inland in the valleys of the rivers Alt and Douglas about 8 miles respectively. They also extend into the valley, in which was formerly Martin Mere, about 7 miles, joining the Douglas valley deposits at Rufford, through a narrow neck. Between Martin Mere and the river Douglas the Boulder-clay rises through the Post-Glacial deposits to a maximum height of 58 feet above Ordnance datum, and occupies an area of about 8½ square miles. The total area of the Post-Glacial deposits lying inland, from high-water mark at the coast-line, forming what I call the Formby plain, is about 75 square miles. Nearly the whole of this plain, though much of it lies below high water, is, through the drainage works of the Alt and those at Crossens, now under cultivation. In Cheshire the equivalents of these deposits form another plain drained by the Birket, a brook falling into Wallasey Pool, the lowest and major part of which pool is now occupied by the Birkenhead Docks. This plain is about 6 miles long at the coast, and has an area, inland of high-water mark, of about 7½ square miles.

In addition to the Formby and Birket plains, there are numerous equivalent formations, such as the Ince and Helsby Marshes in Cheshire, and alluvial or tidal flats fringing the Mersey, and reaching above Warrington; with similar formations on the Dee and Ribble, occupying together many square miles.

Base of the Deposits.—The base upon which the deposits rest is nearly everywhere Boulder-clay, under which occur the sandstones and marls of the Trias. A careful comparison of borings and sinkings at various points has convinced me that at the base of the deposits, and forming the surface upon which they rest, is a Post-Glacial beach cut in the Boulder-clay, and that the valleys of the Alt, the Douglas, and the Rimrose brook pass under the deposits seaward, to a considerable depth below low-water mark; the whole being filled and levelled up with the marine formations and old land-surfaces now under consideration. Borings taken on the Waterloo shore show the clay from 6 to 9 feet below the surface, and other borings show a gradual deepening of the Post-Glacial strata northwards, until at Birkdale it reaches 80 feet; the depth of the strata bearing a pretty constant proportion to the recession inland of the 25-feet contour line. A well-sinking at Seaforth Station showed 40 feet of peat and 10 feet of silicious silt, without reaching the Boulder-clay or the rock, showing that the Rimrose brook formerly, when the land was elevated, flowed down a deep and narrow gulley, now levelled up. Again, at Rufford, piles were driven 70 feet into the silts without bottoming them, proving that the Douglas, at the same period, also flowed down a deep valley now silted up; and, as its mouth now bottoms on the Boulder-clay, and the river is nearly empty at low water, after the silting up, it must have worked its course to the westward and cut out the cliffs of Boulder-clay forming its west or left bank at Hesketh. The valley of the old Wallasey Pool, that of the river Weaver, and numerous tributaries along the Mersey, now silted up, all go to prove that the land was, previously to the Post-Glacial deposits, considerably elevated, as these valleys could only be cut down vertically by sub-aerial action; though, I believe, they have been considerably widened and modified by marine denudation.

Washed-Drift Sand.—Evidences of a very considerable submergence of the land are tolerably abundant in districts adjacent to the one under consideration, marine shells having been found in stratified beds of sand and gravel up to 400 feet high on the Ribble, 1200 feet at Macclesfield, and 1300 feet on Moel Tryfaen in Wales; on the opposite side of the Irish Sea on the Three Rocks Mountain, at Kingston at 1200 feet high, and I believe, also, in elevated positions in the Isle of Man. These shells consist wholly of recent species, but some of them are of a northern character, indicating colder conditions than at present obtain. Their exact position in relation to the Boulder-clay of Lancashire has not yet, that I can ascertain, been clearly made out, and demands much closer attention than has hitherto been given to the question. Judging from the physical appearance of Lancashire and Cheshire, I have slowly arrived at the opinion that since the laying down of the Boulder-clay, it has been elevated and again submerged, as its surface presents what can only be planes of marine denudation.[1] While, on the other hand, the valleys before alluded to, now filled up with Post-Glacial deposits, and also the main valley of the Mersey, had, undoubtedly, been excavated their full depth before any of these Post-Glacial depositions took place. The width of these valleys is too great, and the slopes of their sides too gradual, to be due to sub-aerial influences alone. Nor could they, in my opinion, have been formed during the first emergence of the Boulder-clays from under the sea, as I fail to understand how, in that case, they could have been cut down to their present depth. A considerable Post-Boulder-Clay submersion of the land, previous to any of the deposits I am about to describe, has, therefore, I venture to think, taken place. Whether this interval of elevation and submergence is accepted or not, the Boulder-clay has, undoubtedly, suffered much marine denudation, and the effect has been the elimination from it of what I have termed, in allusion to its derivation, *washed-drift sand,* under which term I include the Shirdley Hill sand of De Rance[2] and the upper drift sand of local geologists. Possibly the forest sand of Binney[3] and the superficial sand described

[1] Chambers calls them terraces. See Ancient Sea Margins, p. 224.
[2] Explanation of Geological Map, 90 S.E.
[3] "Drift Deposits of Manchester and its Neighbourhood."—Manchester Literary and Philosophical Society's Memoirs, vol. viii.

by Trimmer[1] may be due to the same agency. The Esker drift in Ireland is perhaps synchronous with the washed drift sand, and is probably also a reconstructed deposit. An examination of numerous excavations has shown me that the *washed drift sand*, in its normal position, rests on thin beds of reconstructed gravel, lying on the Boulder-clay; but that having been subject to sub-aerial denudation, much of it has been removed and displaced, as shown by the intercalated soil and peat-beds which it occasionally contains. I have traced it along the coast-line and inland, the whole distance between the river Douglas and Warrington. It is found under the mosses at Martin Mere, Rainford and Bickerstaffe, and is generally well developed along the 25-foot contour, from Scarisbrick to between Hill House Altcar, and Downholland Cross. Thence it follows the valley of the Alt, and lies in places 15 feet deep below Clock-house Bridge, and also on the Aintree race-course. At little Crosby the construction of a sewer showed a considerable extent and depth, containing intercalated land-surfaces, and also a seam of gravel several feet above its bottom. It caps the Boulder-cliffs from Aigburth to Hale, and is generally distributed in patches over a wide extent of country. It is a quartzose sand, remarkably homogeneous in character and free from pebbles, and its organic contents, as far as I have hitherto been able to discover, consist wholly of vegetable remains. It varies in colour from a bright yellow to a deep chocolate and a pure white.

Inferior Peat-Bed and Subterrene Land-Surface.—On the coast of Cheshire, between Leasowe and Meols, are to be seen exposed the remains of two peat and forest beds—which evidently mark two periods of elevation—divided by a blue clay or silt, containing *Scrobicularia piperata* and other marine or estuarine forms. A boring at the Palace Hotel, Birkdale, showed, at a depth of 78 feet 6 inches, a bed of mixed blue clay and peat, 18 inches thick, lying on the Boulder-clay, evidently due to the denudation and destruction of a land-surface contemporaneous with the lower forest bed in Cheshire. The intercalated soil-bed, with tree stumps erect therein, contained in the washed-drift sand behind Crosby Hall, I also consider of the same age, as it underlies a continuation of the upper or superior peat-bed; and in a section of the excavations for the foundations of the Liverpool Custom House[2] the inferior peat and forest bed is also shown, resting on the rock about 40 feet below high-water mark, and is divided from the superior peat-bed by 10 feet of blue silt. As the inferior-peat bed has been subject to great denudation, it is only found in favourable and protected spots. At Bewsey Valley, Warrington, a peat and forest bed, described by Mr. Paterson, from 5 to 6 feet thick, from which was taken out the skull of a bear, was exposed by the excavations for the piers of the new railway viaduct.[3] On examining it in a later excavation by one of the piers, I found overlying the peat a fine grey tenacious clay, remarkable as being the only clay in which were present segregated particles of

[1] "On the Erratic Tertiaries, etc.," Quart. Journ. Geol. Soc., 1851, vol. vii. p. 201.
[2] Geology of the Country around Liverpool. Morton, p. 46.
[3] Paper on the "Geology of the Bewsey Valley."—Paterson.

phosphate of iron, of a brilliant blue colour. This mineral I have found occasionally on the surface of bones taken out of peaty soil-beds; and at Birkdale, at one point immediately under the peat, small concretionary lumps of clay contained it. It appears to be due to the partial deoxidation of peroxide of iron, caused by decomposing vegetable matter, and the union of the iron with phosphorus left in the clay in the form of phosphates by decomposing animal matter. Near the peat the phosphate of iron is more largely developed. Under the microscope this clay showed *Triceratium favus*—a marine or brackish water diatom. For reasons which I have not space to detail here, I am inclined to correlate this peat with the *Inferior Peat Bed.*[1] Doubtless much more of this ancient land-surface would be brought to light were excavations made in creeks now filled up, which from their position were formerly protected from the full forces of the tides.

Formby and Leasowe Marine Beds.—Lying upon the denuded surface of the inferior peat-bed, or where its destruction has been complete, upon either the washed-drift sand or thin beds of re-assorted gravel, resting on the Boulder-clay, or in some cases upon the bare Triassic rocks, are a most important group of Post-Glacial deposits.

That the whole group is of marine origin I have fully satisfied myself,[2] having found marine shells in these beds under the superior peat and forest bed, exposed by tidal action at the mouth of the Alt, in the equivalent laminated grey clay at Birkdale, and in the clay and silts between the inferior and superior peat-beds all along the Cheshire coast. Marine shells were also found in cutting the sluices between Formby and Ainsdale, and 20 feet deep in a well at Hightown. Among the shells which I have found in Lancashire are *Scrobicularia piperata, Tellina solidula, Turritella communis, Natica monilifera* and *Cardium edule.* In Cheshire there is a greater variety. No extinct species of shells or Arctic forms have been found in these deposits. A diligent microscopical investigation of a great many specimens from different localities has also disclosed, in nearly all cases where the marine shells are absent, either Foraminifera, among which Rotalias are the most frequent, or marine or estuarine forms of Diatomaceæ. Six feet below the superior peat-bed and 3 miles inland, at Formby, I found Foraminifera in the laminated blue clay, as also in a specimen taken from two feet below the sub-marine forest of the Alt. Mr. F. Kitton, of Norwich, who has kindly examined my specimens, detected in them the following Diatomaceæ, all forms which live only in salt or brackish water: *Triceratium favus, T. striolatum, Coscinodiscus radiatus, Melosira Borreii, Podosira maculata, Tryblionella gracilis, Nitzchia Brebissonii, Navicula Jennerii, N. minu-*

[1] Mr. Vawser, Borough Engineer of Warrington, tells me the surface of the ground is between 19 and 20 feet above Ordnance datum.

[2] Mr. Chas. De Rance considers it to be a fresh-water deposit, and has termed it *Cyclas clay*, and it is so called on the Map 90 S.E.; but he must have been misled by finding dead shells of *Cyclas cornea* thrown out in cleaning the drains or sluices excavated through the peat into the blue clay.

tula, *N. didyma*, *N. Westii* and *Pleurosigma Balticum*. The evidence of marine origin is almost everywhere of the most conclusive character, though probably not accessible to all observers.

The blue clay, locally known as "Scotch," varies from a tenacity suitable for making bricks to that of a looser or more silty and siliceous character. This laminated clay has evidently been laid down in quiet waters or embayments, and, in boring through it, it invariably, if of sufficient depth, gradually passes into a fine siliceous silt. In certain localities, as between the Alt mouth and the sub-marine forest, are local beds of sand; and the nature of the beds in other places passes from sand through silt to blue clay. For these reasons, a comprehensive term is desirable, and I have therefore proposed to call them the Formby and Leasowe Marine Beds. The one name representing Lancashire and the other Cheshire—both places being central in their respective districts. The depth of the deposits in places exceeds 70 feet, and, having levelled up the beach and valleys of the Boulder-clay, that portion inland of high-water mark is represented, I should say, by the space included between the Boulder-clay base and a horizontal plane about 10 feet above Ordnance datum.

The most frequent mammalian remains found in these beds, but which are also common to the overlying peat-bed and recent silts, are those of the *Cervus elaphus* or red deer. There have also been found in both the skulls of *Bos longifrons*, *Bos primigenius*, and bones of a small variety of *Equus*, and of the dog or wolf. Bones of *Cetaceans* occur, as far as I have been able to ascertain, only in the recent silts. From physical reasons I some time since came to the conclusion that these deposits had taken place when the land was relatively lower to the sea than now; and having found at Leasowe, below the superior peat-bed, a bed of *Scrobicularia piperata*, evidently where they had lived and died, at about high-water mark of spring-tides, this fact seems to conclusively settle the matter. I am, therefore, of opinion that high-water mark was then at or about the 25-feet contour line. The area of these deposits, exclusive of those in the Mersey itself, is in Lancashire about 75 and in Cheshire 7½ square miles, the same as previously stated, for the whole series of these deposits on the coast, below the 25-feet contour line, and inland of high-water mark.

Superior Peat and Forest Bed.—After the Formby and Leasowe marine-beds had been laid down, the land became gradually elevated and subject to sub-aerial influences, which partially moulded and modified the form of the now dry land. The sea would leave the surface in long undulations, thereby determining to some extent the water-beds and new river valleys, though the persistence of the old valleys is certainly remarkable. The cutting of the back drain at Crossens discloses what is evidently an old river-bed, now silted up, the bottom of which is certainly not less than 10 feet below Ordnance datum, and therefore considerably below the bed of either the Alt or Douglas, and probably drained the site of Martin Mere and a large extent of country to the southward. This river-bed, at the point named, is cut through the Boulder-clay, and I ascribe its formation to sub-aerial aqueous erosion during this the last period of elevation. The superior peat and forest bed lies upon the Formby and Leasowe marine-beds, and contains at its base the remains of an ancient forest or forests. The oak, pine, hazel, alder, birch, etc., are among the trees found in it, and may be seen with stumps erect and roots striking deeply down into the blue clay at the Alt mouth. In some places only the roots are seen striking into the clay, the bole having rotted away and the roots being only covered by a thin layer of peat.

With this bed I correlate the peat-bed of old Wallasey Pool, now occupied by the Birkenhead Docks, the 40 feet of peat filling up the Rimrose gulley, the peat-beds under the blown sand at Waterloo, the upper bed in the Custom House section, before referred to, the land-surface of the little creek at Garston, and the beds covering nearly the whole areas of the previously-mentioned deposits; the average depth of which will probably be about 7 feet, though in some localities 12, and in one North of Scarisbrick 20 feet thick. The inland margin rests generally upon the washed-drift sand, as also does part of the peat near Martin Mere.

Recent Deposits.—Since the last-mentioned forest grew, the land has gradually subsided to its present level, and probably the resulting obstruction to the drainage has been the cause to a large extent of the peat-beds. That part of the peat is due to this cause is proved by the occasional intercalated beds of silt, in one case at Birkdale containing marine shells.[1] A long pause (certainly in commencement Pre-Roman) ensued, as is shown by the levelling up of all the depressions of the superior-peat bed with marine or tidal silts, assisted by alluvium brought down by rivers during floods. This levelling is so complete, and from the levels the later stages of it must have been so slow, that it measures a very considerable lapse of time. Bones of *Cetaceans* have been found in this silt in excavations for the Liverpool and the Birkenhead Docks.

Denudation and deposition invariably go together, and we find that below tidal mark the superior peat and forest bed has itself been subject to great denudation, being only preserved where occurring in sheltered inlets or creeks. That the land on the Cheshire coast extended considerably seawards I consider an incontestable fact. Areas of deposition and denudation are also continually changing. and consequently we find recent deposits in places where the former land-surface had been denuded; and this change, it must be borne in mind, takes place without any relative alteration of the levels of sea and land.

Blown Sand.—Among the most recent deposits is that of blown sand covering the superior peat-bed to a considerable distance inland all along the coasts of Lancashire and Cheshire, and rising into high sand dunes as it fringes the sea-margin. The present shore being so extremely flat is eminently favourable to the generation of blown

[1] Mr. Binney and Mr. Talbot also found an intercalated bed of blue silt by Downholland Brook.—See "On the Petroleum found in Downholland Moss," Manchester Geological Society's Proceedings, March, 1843.

sand, the drifting occurring mostly between neap and spring tides, when a large extent of the shore is bare and dry. When the sand first began to blow is an interesting problem difficult to solve; for though Roman remains are found at the base of the Sandhills in Cheshire, this does not settle the question, as there may have been sand dunes to the northward on the new land which have since encroached landward. In places also there are beds containing fresh water or marsh shells, but I do not consider these general and intercalated; in the blown sand are traces of former cultivated soil-surfaces.

General Conclusions.—A careful consideration of the foregoing facts, of which only a bare outline is given, has enabled me to come to the following conclusions.

1st. That since the laying down of the Boulder-clay, the land has been elevated above its present level, and has been again depressed considerably below it, the main portion of the present Lancashire and Cheshire river valleys having been excavated during this period and the subsequent re-emergence of the land. The *washed-drift sand* was eliminated from, sorted and re-formed out of the Boulder-drift, and scattered over the country, but has been much denuded and displaced since by atmospheric and aqueous influences above the 25-feet contour, and by sub-aerial and sub-marine denudation below that line.

2nd. On re-emergence the land was again elevated above its present level, and a pause favourable to growth occurred, during which time the "*inferior peat and forest beds*" or subterrene land-surfaces were formed. The vertical extent of this and after-movements will be considered at a future time.

3rd. A second period of subsidence followed, and a pause occurred at or about the 25-feet contour line; considerable denudation of the *inferior peat* took place, and afterwards, the *Formby and Leasowe marine beds* were laid down.

4th. The latest vertical upward movement succeeded the formation of the *Formby and Leasowe marine-beds,* and upon them, as a land-surface, grew the forest trees, remains of which are seen at the base of the *superior peat-bed.* They are traceable from the mouth of the Douglas, by Formby and Waterloo, to a little creek at Garston, and on the opposite Cheshire shore from the Mersey to the Dee, and as far up the Mersey as the Ince and Helsby marshes and the mouth of the River Weaver. The river-bed at Crossens was excavated during this period of elevation.

5th. The last movement of the land now took place and was downwards. The river-bed at Crossens was silted up, and the drainage of Martin Mere reversed into the Douglas. The drainage generally was obstructed, and here and there beds of tidal silt were intercalated in the growing peat. The tidal silt overlying the superior peat-bed by the Douglas, the Alt and the Birket, the silt which overlay the peat-bed of old Wallasey Pool, and that in which the vertebra of a whale, now in Brown's Museum, was discovered at the North Docks, and all the deposits to which I confine the term *recent,* belong to this period, in a pause of which we are now living. These silts are again in places being denuded or "*fretted*" away, and though there is and has been since the Roman occupation a cessation of vertical movement in the land, horizontal displacements by erosion and re-formations by deposition are still taking place, due solely to changes of tidal and river currents—agencies capable of affecting much greater change than is usually supposed, and the effects of which, even within the limits of the last century, I hope at some future time to show are capable of measurement and exact calculation.

VI.—On Subsidence as the Effect of Accumulation.[1]

By Charles Ricketts, M.D., F.G.S.

THE majority of geological formations have certainly been deposited in what was at their respective periods the sea; but Sir Charles Lyell, Prof. Geikie and others have shown that the action of the waves and currents upon sea-cliffs, and their power to remove matter from above to below the sea-level, is very insignificant compared with that effected by atmospheric agents, by rain and rivers, in the interior, in consequence of the immensely more extended area upon which these act; so that, even supposing the height of ancient cliffs to have been very much greater than those of the present time, which have been considered to average not more than twenty-five feet, it appears difficult or rather impossible to attribute the origin of the materials of which they consist, sometimes amounting to several miles in thickness, to the erosion of coast-lines, with the exception of a comparatively thin stratum situated at their base. Those who have ascribed their origin to marine denudation have given no satisfactory explanation of the manner in which the *débris* from the disintegration of the cliffs has been redistributed to form these strata.

In determining the source whence the deposits entering into the composition of Palæozoic rocks have been derived, attention must be directed to the frequent recurrence, at or near the base of these formations, of evidences of deposition in shallow water, such as ripple-marks, sun-cracks, tracks of annelids, etc., current-bedded strata, and conglomerates, whilst an accumulation of materials has subsequently occurred amounting it may be to several miles in thickness; thus proving that, simultaneously with the deposit, subsidence of the land has taken place to at least as great an extent as the whole thickness of the superincumbent strata. It therefore follows that if the then contour of the land was similar to the present, though the beds at the base may at their formation have been situated near the shore-margin, those overlying them, but separated by this great thickness of strata, must in consequence of the subsidence have been deposited at a distance of very many miles from the coast, so far that by no possibility could the sediment have been derived from marine denudation acting on cliffs.

[1] An Abstract of a Paper read before the Liverpool Geological Society, as the President's Address for the Session 1871–72.

The ancients considered the formation of valleys to have been dependent on atmospheric denudation; that they have been excavated by running water, and that floods have washed down hills into the sea. This opinion was advocated by Hutton and Playfair. By others their origin has been variously attributed to the effects of a great flood, notably the Noachian deluge;—to marine action;—that they are situated and dependent on lines of curvature, dislocation, and fracture; but none who have respectively advocated these opinions give an explanation of the manner by which the materials, which once filled up valleys, have been removed. Within the last few years the opinions of Hutton and Playfair have been revived, more particular attention having been directed to the subject in 1853 by Colonel George Greenwood, in his work entitled "Rain and Rivers." These views have since been advocated by the late Prof. Jukes, and by Profs. Ramsay and Geikie, whilst numerous communications and essays have appeared in the pages of the GEOLOGICAL MAGAZINE from the members of the staff of the Geological Survey and other observers. These consider that valleys have in all cases been excavated by subaërial agencies, including ice and glaciers, the *débris* being carried forwards towards the sea by rain and rivers. This is the only theory by which a satisfactory explanation can be given to account for the redistribution of the materials which have been abraded from the sides of valleys.

It is almost universally conceded that perennial snow has existed, and that glaciers have extended over districts much farther south than at the present time; to this ice-action much of the existing contour of the land is to be attributed. In the neighbourhood of Liverpool the Triassic rocks on each side of the Mersey are extensively smoothed, grooved, and striated by this glacial action, these markings in a comparatively soft sandstone having been preserved by the deposition of the materials (sand and the Boulder-clay) resulting from the grinding motion of the glaciers, which, in a similar manner to what is now occurring in Greenland, issued as sub-glacial rivers thickly loaded with mud and flowing into the sea, discoloured the waters for miles and was eventually deposited on the bottom as a thick coating of clay.[1] A very considerable subsidence of the land is known to have occurred during this Glacial period, both here and in other parts of Britain; this depression may be attributed to the combined weight of ice and the Boulder-clay pressing down the surface to below the sea-level; the land being again raised to a considerable extent when, upon the return of a more genial climate, it was relieved of its load of ice and snow. A similar subsidence is now in progress in Greenland, for the ruins of houses and factories may be seen in places now entirely submerged at high-water, and simultaneously there exists an increased severity of the climate and an increase of the accumulation of snow.

The formation of Deltas and alluvial plains has been considered, even from the time of Herodotus, to be due to deposits brought down

[1] Dr. Robert Brown, Physics of Arctic Ice. Quart. Journ. Geol. Soc., vol. xxvi. p. 682.

by rivers. The great historian imagined that the area in which is situated the Delta of the Nile was formerly a deep sea, which had been gradually filled up by deposition from the river, and many geologists consider that it is under such conditions that delta-accumulations occur. Borings have been made in the case of the Po to 400 feet, in the Ganges to 481 feet, and in the Mississippi to 630 feet, through strata generally fluviatile, having near the lowest depths which were reached beds of turf and other vegetable matter, and which, therefore, must at one time have formed a land surface. As an alluvial plain is situated in an extension of a valley, and a delta is an extension of the plain, being situated in what is a continuation of the same valley, it follows that the area in which the delta-accumulation occurs has, prior to the deposition, been excavated by the same causes which have excavated the valley, and these have been shown to be sub-aërial. As deltas and other evidences of subsidence occur so generally near the mouths of great rivers, whenever any great amount of sediment is brought down by the streams, it appears impossible not to consider that the depression is dependent on and caused by the accumulation; that as layer after layer of mud and sand has been deposited in the deltas and neighbouring seas, the constant addition of fresh material causes by its weight a subsidence which is generally gradual and imperceptible, but, under certain conditions, may occasionally occur suddenly and be accompanied by earthquakes, as in the basin of the Mississippi near New Madrid, in 1812.

The production of Bays has not unfrequently been attributed to the effects of waves and marine currents; but such a theory when applied, as it has been to the Gulf of Mexico, pre-supposes so great an erosive action as to have excavated the land to depths of from one to two miles, as well as the redistribution to some other locality of the materials removed. It will be seen that in almost every instance bays have rivers flowing into them, and appear as if they form a continuation of their valleys, being wide in accordance with the width of the valley; also, contrary to what might be expected, the water at least sometimes, as in the Ganges and Mississippi, becomes very rapidly deeper where the deltas are greatest, and the greatest amount of sediment is being deposited. To account for their formation it will require the occurrence of a subsidence of the land to a greater extent than the valley can be filled up by the sediment brought down by the river.

An Estuary may be described as a bay situated in what was once a narrow valley or gorge, and like a bay is the result of subsidence of the land, by which the river-bed has been depressed below the sea-level so that the waters fill it up, in a similar manner to what occurs if an embankment is constructed across a similar narrow portion of a valley, with the addition of the changes which occur in the level of the water according to the state of the tide.

It is evident that the agency by which the estuary of the Mersey has been excavated has been sub-aërial. The smoothed, planed and striated surfaces which are found on each side of the valley beneath the Boulder-clay lead to the inference that the more ancient valley has to a great extent resulted from the eroding power of ice; as this arctic temperature continued the land subsided to a considerable extent below the present sea-level, and whilst thus submerged the sand and clay escaping from beneath the glaciers were spread over what had become the bed of an extensive ice-bound bay. The climate changing and the glaciers becoming dissolved, the land, relieved of its icy burden, became raised considerably above its present level, and what is now our harbour was covered with a luxuriaut vegetation, the river running through it probably as a narrow stream; but as the sand and silt brought down by this and other rivers were deposited in the bay, and as the accumulation became greater, the influence of its pressure was extended more inland, so that the valley on being depressed, instead of conveying a small stream, became the lateral boundaries of the present estuary.

There may be a difficulty in all cases of proving that the denudation of continents has been continuous, but of this there can be little doubt respecting a large portion of North America. Those who have perused the report of the United States expedition to the Colorado river, will agree with Prof. Newberry in his conclusions that the district could not have been submerged since the time when the waters began to cut deeply into the Carboniferous limestones and sandstones which constitute the Colorado plateau; thus forming those enormous gorges the Cañons of the Colorado, having perpendicular walls from 3000 to 6000 feet in height. Confirmation of this opinion was afforded by Prof. Marsh in a tour made last year in the Rocky Mountain region, and along the tributaries of the Colorado River in Utah, where extensive freshwater lakes existed during the Tertiary Period (Geol. Mag. 1871, p. 127). Therefore the land situated at the same height on the opposite flanks of the mountains must also, during the same time, have been far above the sea-level, and must likewise during the whole of this extended period have been exposed to denudation from atmospheric agencies alone.

If the crust of the earth formed a rigid surface so that neither elevation nor depression could take place, then, instead of deltas which represent comparatively a minute portion of the enormous amount which is known to have been removed from what constitute the valley systems of large rivers, there would be enormous plains extending for hundreds or rather thousands of miles, when the areas exposed to denudation are so great as nearly half a million of square miles in the case of the Ganges and Brahmapootra, or nearly a million in that of the Mississippi and Missouri.

Considering that the formation of deltas and bays is the result of depression caused by the weight of sediment derived from the disintegration of interior land surfaces brought down by rivers, it will likewise be necessary to attribute the extension of the bays towards the ocean to a previous existence of the same causes and that their river-systems were formerly greatly extended, receiving as tributaries rivers which now empty themselves into bays, and others flowing over land now submerged to a great depth, and which is, moreover, covered with thick deposits forming the beds on which rest the waters of these extensive gulfs; therefore there must be now in progress in different parts of the world formations which will at least rival any recorded in Britain as having occurred in Palæozoic times. It may be presumed that the Ganges at one time has extended southward to 10° or perhaps even to 5° north latitude; that the Mississippi has in all probability extended as far as the longitude of Porto Rico. By the same reasoning the rivers now emptying themselves into the Bay of Liverpool—the Lune, Ribble, Mersey, Dee, Clwyd, and others—will, prior to the Glacial period, have all converged and formed one large river emptying itself into what is now the Irish Sea.

If valleys have been formed, and inland areas and mountain chains sculptured, by what is known as sub-äerial agencies, there appears to be no other way than that advanced to account for the re-distribution of the materials which have been removed. The phenomena of the accumulation of material and of subsidence of the land are not unfrequently alluded to by Sir Charles Lyell and others as occurring simultaneously; but it appears that none have considered that the one is dependent upon the other, at least in reference to the present subject.[1] If Lyell does not venture to associate the two as cause and effect, it is hardly to be expected that this theory will be accepted without due consideration; but it is a question which demands and deserves a careful examination.

VII.—Notes on Eley's Foraminifera from the English Chalk.

By Prof. T. Rupert Jones, F.G.S., and W. K. Parker, F.R.S., F G.S.

The Foraminifera of the Chalk were treated of in Nos. 89 and 90 of the Geol. Mag., November and December, 1871, with the view of aiding collectors and authors in their arrangement of these numerous and puzzling microzoa in their catalogues and cabinets. We shall be rendering further service to students, if we refer them to the Rev. Henry Eley's clear and useful, though somewhat hard, drawings of the Foraminifera usually found in the English Chalk and Flint. These were published in his "Geology in the Garden; or, the Fossils in the Flint Pebbles." 8vo. London, 1859.

The nomenclature of the Foraminifera having been improved of late years, we correct the names accordingly.

pl. ii. figs. 3 and 4. *Planorbulina ammonoides*, Reuss. Internal casts. p. 193.
— figs. 5 and 6. *Globigerina cretacea*, D'Orb. Internal casts. p. 194.
— fig. 7. *Cristellaria ovalis*, Reuss. Internal cast. p. 194.
— fig. 8. *Cristellaria rotulata*, Lamarck. Internal cast. p. 194.

Fig. 7 has a few large segments, and is oval; fig. 8 has many segments and is lenticular; figs. 7 and 8 are *essentially* the same, as stated by Mr. Eley, but are separated for convenience.

[1] The principle is applied by Sir John Herschel to the subsidence of the bed of the Pacific Ocean and its converse, the elevation of the Andes (Physical Geography § 132), and also by Dr. Dawson, of Montreal, to account for the depression of the strata during the Laurentian Period (*Leisure Hour*, 1871, page 119).

pl. ii. fig. 9. *Textilaria globulosa*, Ehrenberg. Internal cast. p. 194.
— fig. 10. *Textilaria turris*, D'Orb. Internal cast (p. 195) of a somewhat curved individual resembling *Textilaria pinnula*, Ehr. 1854.
— fig. 11. *Bolivina obsoleta*, Eley. Internal cast. p. 195. A thickened and marginate shell. (See pl. 8, f. 11).
— fig. 12. *Virgulina paradoxa*, Ehrenb. Internal cast. p. 195.
pl. iii. fig. 13. *Bolivina* (*punctata*, D'Orb.?). Internal cast. p. 195.
— fig. 14. *Bolivina?* vel *Textilaria?* Section. p. 195.
— fig. 15. *Spiroplecta rosula*, Ehrenb. Section. p. 196.
— fig. 16. *Planulina ariminensis*, D'Orb. Internal cast. p. 196.
— fig. 17. *Planorbulina?* Young. Section. p. 196.
— fig. 18. *Flabellina rugosa*, D'Orb. Internal cast. p. 196.
pl. iv. fig. 19. *Frondicularia Archiaciana*, D'Orb. Internal cast. p. 197.
— fig. 20. *Frondicularia angulosa*, D'Orb. var. Internal cast. p. 197.
— fig. 21. *Dentalina communis*, D'Orb. Cast. p. 197.
— fig. 22. *Verneuilina triquetra*, Münster. Cast. p. 197.
— fig. 23. *Nodosaria raphanus*, Lin. var. *Zippei*, Reuss. Cast. p. 198.
pl. v. figs. 24-26. *Rotalia umbilicata*, D'Orb. Internal casts. p. 198.
— fig. 27. *Pulvinulina Micheliniana*, D'Orb. Internal cast, fragment. p. 198.
— fig. 28. *Rotalia umbilicata*, D'Orb. var. Internal cast. p. 198.
— fig. 29. *Bulimina variabilis*, D'Orb. Cast. p. 198.
— fig. 30. *Bulimina intermedia*, Reuss. Internal cast. p. 199.
— fig. 31. *Verneuilina triquetra*, Münster. Internal cast. p. 199.
pl. vi. fig. 33. *Dentalina communis*, D'Orb. Section. p. 199.
— fig. 34. *Textilaria trochus*, D'Orb. (Narrow var.) Broken cast. p. 199.
— fig. 35. *Rotalia umbilicata*, D'Orb. var. Internal cast. p. 200.
— fig. 36. *Verneuilina triquetra*, Münst. var. between *triquetra* and *pygmæa*. Internal cast. p. 200.
— fig. 37. *Gaudryina rugosa*, D'Orb. Cast, broken. p. 200.
— fig. 38. *Verneuilina triquetra*, Münst. var. between *triquetra* and *pygmæa*. Internal cast. p. 200.
pl. vii. fig. 39. Very minute flint casts (dust), from the inside of a flint nodule, showing sectional views of *Textilaria globulosa*, *Planorbulina ammonoides*, *Cristellaria rotulata*, and separate chambers of *Globigerina*. p. 201.
— fig. 39 *C*. Chalk dust, showing *Textilaria globulosa*, *Globigerina cretacea*, *Polymorphina*, *Planorbulina ammonoides*, and Spicules. p. 201.
pl. viii. fig. 3 *C*. 4 *C*. *A*. *C*. *Planorbulina ammonoides*, Reuss. p. 202.
— fig. 5 *C*. *Globigerina marginata*, Reuss. p. 202.
— fig. 6 *C*. *Globigerina cretacea*, D'Orb. (With a tendency towards *Gl. bulloides*, D'Orb.) p. 202.
— fig. 7 *C*. *Cristellaria rotulata*, Lam. Produced or elongated var. p. 202.
— fig. 8 *C*. *Cristellaria rotulata*, Lam. Lenticular var. p. 202.
— fig. 10 *C*. *Textilaria turris*, D'Orb. p. 202.
— fig. 11 *C*. *Bolivina obsoleta*, Eley. p. 202.
— fig. 12 *C*. *Virgulina paradoxa*, Ehrenb. p. 202.
pl. ix. fig. 9 *C*. *Textilaria globulosa*, Ehrenb. p. 202.
— fig. 15 *C*. *Spiroplecta rosula*, Ehrenb. p. 202.
— fig. 16 *C*. *Planulina ariminensis*, D'Orb. p. 202.
— fig. 18 *C*. *Flabellina rugosa*, D'Orb. p. 202.
— fig. 20 *C*. *Frondicularia angulosa*, D'Orb. var. p. 202.
— fig. 23 *C*. *Nodosaria raphanus*, Linn. p. 202.
— fig. 38 *C*. *Verneuilina triquetra*, Münst. p. 202.

Plates viii. and ix. represent the perfect shells, *casts* of which are figured in the other plates under corresponding numbers.

Plate x. contains some illustrations of recent Foraminifera (see pp. 188 and 202). Thus figs. 41 and 42 are young *Rotalia Beccarii*, of the feeble variety that lives in estuarine and sub-brackish waters. Its shell is thin, and its chambers are not so compactly fitted together as in the well-grown individuals inhabiting deeper sea-water. Mr. Eley's drawings represent the pseudopodia freely exserted. Fig. 43

shows the body (sarcode) of the animal without the shell. Fig. 44 is the empty shell, as a transparent object; the curved edge of the shell is darker, being seen vertically, and falsely appears like a thickened margin. A membranous oval pedunculated sac is attached to one of the chambers; whether this is parasitical, or belongs to the animal as a germ-sac, is unknown. Such a sac has been observed in other instances, recent and fossil, by Ehrenberg. Fig. 45 represents a *Bolivina punctata*, seen by transmitted light. Here also the vertical thickness of the edge is less transparent than the flat walls of the shell, and at first sight looks like a fringed border, but the author fully explains it at p. 203.

Mr. Eley's little book—whence these abstracts have been taken—has been to many an excellent introduction to the study of geology, and contains useful and well-arranged interesting information about alluvium, Post-tertiary, Tertiary, and some Cretaceous strata. The appendix is devoted to a natural history consideration of the Microzoa, Sponges, and other fossils of the Chalk, and is illustrated by several plates. Pl. i. gives Inoceramus prisms and various Sponge Spicules; plates ii. to ix. contain the Foraminifera found in the Chalk and its flint (pseudomorphic chalk); pl. x. has some recent Foraminifera and a Xanthid and a Fish-scale from the Chalk; plates xi. and xii. represent miscellaneous Chalk fossils, chiefly in flint.

We may add that the flint casts of *Planorbulina ammonoides*, above mentioned (pl. ii. figs. 3 and 4), are comparable with the exquisitely engraved figures in Mantell's plate xxi. "Philos. Transact." 1846, where the Molluskite casts and the shells of small *Planorbulinæ* are carefully drawn. These belong to varieties between *Pl. ammonoides* and *Pl. ariminensis*, both Cretaceous and recent. Compare also fig. 29, in pl. ii. of Prof. Williamson's memoir "On some miscroscopical objects from the Levant," etc., in the Manchester Lit. Phil. Soc. Mem., vol. viii., 1847. This is the early (central) portion of *Pl. Mediterranensis.*

Foraminifera from the Chalk of the South-east of England, figured by the Rev. Henry Eley, 1856.

1. *Nodosaria raphanus*, Linn.	1. NODOSARINA.
2. ——— ——— var. *Zippei*, Reuss.	
3. *Dentalina communis*, D'Orb.	
4. *Frondicularia Archiaciana*, D'Orb.	
5. ——— *angulosa*, D'Orb. var.	
6. *Flabellina rugosa*, D'Orb.	
7. *Cristellaria rotulata*, Lam.	
8. ——— *ovalis*, Reuss.	
9. *Polymorphina*, sp. ?	2. POLYMORPHINA.
10. *Bulimina variabilis*, D'Orb.	3. BULIMINA.
11. ——— *intermedia*, Reuss.	
12. *Bolivina punctata*, D'Orb. ?	
13. ——— *obsoleta*, Eley.	
14. *Virgulina paradoxa*, Ehrenb.	
15. *Textilaria globulosa*, Ehrenb.	4. TEXTILARIA.
16. ——— *turris*, D'Orb.	
17. ——— *trochus*, D'Orb.	
18. *Spiroplecta rosula*, Ehrenb.	
19. *Gaudryina rugosa*, D'Orb.	
20. *Verneuilina triquetra*, Münst.	
21. ——— ——— var.	

22. *Globigerina cretacea*, D'Orb 23. ———— *marginata*, Reuss.	5. Globigerina.
24. *Planorbulina ammonoides*, Reuss. 25. *Planulina ariminensis*, D'Orb.	6. Planorbulina.
26. *Pulvinulina Micheliniana*, D'Orb.	7. Pulvinulina.
27. *Rotalia umbilicata*, D'Orb.	8. Rotalia.

NOTICES OF MEMOIRS.

I.—Geology of New Hampshire.

IN 1868 a Geological Survey of the State of New Hampshire, U.S.A., was ordered by the Legislature. C. H. Hitchcock was appointed Director; J. H. Huntington, G. L. Vose, Geological Assistants; C. A. Seely, Chemist; and Arthur M. Edwards, Microscopist. Three brief annual reports of progress have been made, amounting in the aggregate to 155 pages octavo, with two maps; the first of the *Ammonoome Gold Field*, and the second one of the whole State, upon the scale of ten miles to the inch, designed to show the distribution of granite and the progress of triangulation for the year 1870. The latter map shows nine geological distinctions.

The work performed has been geological, topographical, and meteorological. As no good maps existed, the first object aimed at was the determination of the exact geodetical points by triangulation. Using the stations of the Coast Survey for a basis, E. T. Quimby and G. L. Vose made satisfactory progress in establishing the latitudes and longitudes of several prominent mountain peaks. The former gentleman is continuing the work under the direction of the United States Coast Survey, who are authorized by Congress to expend funds for triangulation in all interior States where Geological Surveys are in progress. A new map of the whole State, upon the scale of two miles and a half to the inch, which will serve as the basis for the geological delineation, is nearly ready for the engraver. Models of the White and Franconia Mountains have been executed in plaster, upon a large scale.

The second report gives a general classification of the rocks. The geology of this State is so intricate that no one has ever attempted to map the formations. Maps of the northern part of the Continent, such as Logan's, leave this territory entirely blank, unless they be on a minute scale like Lyell's, or E. Hitchcock's maps of the United States (1853), where it all appears as "Primary." It has, however, been the field for conflicting theories. We have first the ancient idea of a central granitic nucleus, illustrated by Jackson's Report and all earlier writers. Succeeding this came a general belief that the gneisses and granites were "Primary." Subsequently most American geologists adopted the theory that the New England gneisses were all metamorphosed Palæozoic strata; and Logan, Sterry Hunt and J. P. Lesley are on record as affirming the rocks of the White Mountains to be Devonian. The researches of the present Survey indicate a return to the older view that these rocks are largely Eozoic. The discoveries of the past year (1871), not yet reported, seem to confirm the anticipations of the printed statements. Without giving the reasons for new views, the following may be presented as the probable ages and arrangements of these metamorphic groups.

First, of *Laurentian* age, is a central and interrupted area of Porphyritic gneiss and granite. This is flanked in the more southern counties by wide bands of gneiss, having similar mineralogical characters upon both sides, each capable of satisfactory subdivision. Next come several isolated patches of the *Labradorian* group of the Canada Survey, or the *Norian* [1] of Hunt, characterized chiefly by the presence of the mineral labradorite, now for the first time discovered *in sitû* in New England. An extensive compound of labradorite and chrysolite has received the name of *Ossipyte.*[2] An extensive series of felsites, granites and jaspers seem to belong nearly to this period. Next is a large amount of *Andalusite gneiss,* found both among the White Mountains and in the southern districts. This has been referred to the "White Mountain Series," or the Lower Cambrian, by Dr. Sterry Hunt, in his Address before the American Association for the Advancement of Science, 1871. It seems to be stratigraphically distinct from the Norian rocks, though not so easily separated from the supposed Laurentian gneisses. All the rocks thus far mentioned are clearly Eozoic, and unconformably underlie all the others. Apparently the lowest of the Palæozoic division is the series of slates and schists, to which the name of *Coös group* has been given in the second report. This is synonymous with Hunt's *Terranovan series* in part, by him referred to the base of the Silurian. In New Hampshire this group contains the minerals andalusite, staurolite, and syenite in great abundance; or silicates of alumina without alkalies. A great band of it lies along Connecticut river for over a hundred miles, invariably resting upon the edges of the Eozoic gneisses. Its stratigraphical relations were determined before the suggestion of the term Terranovan. A band of mica-schist and quartzites along the Merrimack river must be of nearly the same age. This "Merrimack group" occasionally carries andalusite schists, and crops out upon Mounts Pequawket and Washington. Next come the green schists usually called talcose, and the equivalent of the metamorphic portion of the "Quebec Group" of Sir W. E. Logan. This is found along Connecticut river, widening in the extreme northern part of the State. Recently Credner, Macfarlane, and Hunt have referred this talcose band to the Huronian of Logan, which is probably Eozoic. Scattered over this Quebec area are several patches of clay-slates; two of the "Calciferous Mica Schist" of the Vermont Reports, and one of Helderberg limestone (Devonian), with fossils. The slates are allied to the "Gaspe slates" of Canada, which are thought to be Upper Silurian. Logan refers the mica-schists to the same age.

New Hampshire furnishes a fine field for the study of the markings left during the Glacial period. Transported boulders have been discovered 5,800 feet above the sea-level upon Mount Washington. The striæ at 5,200 feet course south-easterly, and indicate that the ice moved up and over the peaks. In other parts of the State the striæ

[1] Amer. Journ. Sci., ii., vol. xlix., p. 180. [2] Ibid., iii., vol. iii., p. 49.

seem to have followed the directions of the greater valleys, whether east, south-east, south, or S. 20° W. Along the sea-shore are marine deposits of the Champlain or Post-Pliocene period.

The meteorological work consisted in the establishment of an observatory, during the winter of 1870–71, upon the summit of Mount Washington, 6293 feet above the sea, the station being subsequently adopted by the "Signal Service of the War Department" of the General Government. The experiences of the party resembled greatly those reported by explorers in the Arctic zone. The observations were reported daily for the press, and have been printed in the Geological Report for 1870, as well as a popular account of the writer's experiences, entitled "Mount Washington in Winter." Boston.

II.—Notes on the Geology and Mineralogy of the Island of Lundy. By Townshend M. Hall, F.G.S.

[Transactions of the Devonshire Association for 1871.]

REFERRING first to previous geological observations on the Island, the author then describes its Physical Geography and Geological Structure.

The principal part of Lundy Island is composed of granite, the south-eastern corner, however, consists of slate. In their petrological characters, as well as in their general appearance, these silvery slates closely resemble those of Ilfracombe or Morthoe in the North Devonian group. Judging, however, from the general east and west strike of the North Devon series, these Lundy Island slates would naturally come on the horizon of either the Pilton-beds (uppermost Devonian), or the Carboniferous shales (or Culm-measures) of the mainland, which Mr. Hall regards as occupying a position between the Devonian and the Millstone Grit. No fossils having hitherto been discovered in Lundy, it is found most difficult to prove to which of the two systems the slates should be referred, especially as in North Devon the two great systems (as Mr. Hall remarks) pass quite insensibly one into the other, without any distinct line of separation between them—a fact of great importance in the grand Devonian question.

That the slates of Lundy existed before the intrusion of the granite is shown by the very abrupt manner in which they are cut off by it. The granite is generally similar to the other isolated masses of the same rock in the west of England. Schorl is not abundant as a component, but there are occasionally thin irregular veins of a fine grained granitic substance (eurite?) traversing the rock. Many years ago the Rev. D. Williams described the granite of Lundy as occupying a dyke having a north-east and south-west direction, having a similarity, as regards mode of occurrence, to the little patch of granite or syenite which Mr. Leonard Horner first pointed out at Hestercombe, near Taunton, 69 miles distant. These granites are therefore different from the "domes" or larger masses in Devon and Cornwall. Mr. Hall discusses the connection which has been supposed to exist between these two granitic dykes. Their eruption he considers to have taken place since the deposition of the Carboniferous strata.

Another feature in the geology of Lundy is the occurrence of intrusive dykes of greenstone, which penetrate both the granite and slate.

Mr. Hall gives also a list of the minerals found in the Island. In the granite there occur Beryl, Felspar, Fluor, Garnet, Mica, Rock Crystal, and Schorl. In the slates are found Blende, Towanite, Magnetite, Quartz, and a Zeolite. H. B. W.

III.—List of Minerals found in Somersetshire.

By Horace B. Woodward, F.G.S.

The subjoined list of minerals occurring in Somersetshire is chiefly compiled from "Bristow's Glossary of Mineralogy;" "Hall's Mineralogist's Directory;" a MS. Catalogue of Minerals from West Somerset, by S. G. Perceval, preserved in the Taunton Museum; the publications of the Geological Society of London, etc. It may perhaps prove useful to local observers. H. B. W.

Alabaster	*Rhætic*, *Keuper*. Watchet; Near Somerton.
Amethyst	*Dolomitic Conglomerate*, Near Bristol, Cheddar.
Aragonite	*Keuper*, *Devonian*, Broomfield, Near Cutcombe, Blue Anchor, Taunton.
Barytes	*Lias*, Harptree. *Keuper*, *Mountain Limestone*, Clevedon, Dolberry, Watchet, Nether Stowey, Doddington.
Bornite	Broomfield.
Calamine	*Dolomitic Conglomerate*, *Mountain Limestone*, Mendips, Broadfield Down.
Calcite	*Passim*.
Celestine	*Oolite*, Collier's Lane, near Bath. *Keuper*, Bedminster, Chew Magna, Wells, Blue Anchor, Watchet.
Chalybite, Spathose Iron Ore	*Devonian*, Exmoor, Brendon.
Chessylite	*Devonian* (?), Doddington, Nether Stowey.
Copper	Broomfield, Hutton, Near Wookey Hole.
Copperas	*Fuller's Earth*, Widcombe.
Galena (Argentiferous)	*Oolite*, *Lias*, *Rhætic*, *Dolomitic Conglomerate*, *Mountain Limestone*, Mendips, Broadfield Down. *Devonian*, Treborough.
Göthite	Near Bristol. *Devonian*, Exmoor, Raleigh's Cross.
Hematite	*Mountain Limestone*, Mendips. *Devonian*, Main Down, Brendon, Porlock.
Leadhillite	*Devonian* (?), Kingston, near Taunton.
Limonite	*Mountain Limestone*, Mendips. *Devonian*, Brendon, Exmoor.
Malachite	*Devonian* (?), Doddington, Nether Stowey.
Manganese	*Mountain Limestone*, Shutshelve, Wookey Hole, Near East Harptree. *Devonian*, Raleigh's Cross.
Manganite	Near Bristol, Mendips, Churchill, etc.
Mendipite	Churchill.
Mimetene	Near Blagdon. (Mr. R. H. Valpy, F.G.S.)
Psilomelane	Mendips. *Devonian*, Brendon.
Pyrites	*Passim*.
Quartz	*Passim*.
Rock Salt	Pseudomorphous crystals. *Rhætic*, *Keuper*, Wells.
Selenite	*Lias*, *Rhætic*, *Passim*.
Smithsonite	*Mountain Limestone*, near Bristol, Mendips, Shipham, etc.
Specular Iron Ore	*Devonian*, Raleigh's Cross.
Wulfenite (?)	Churchill.

[1] "Drift Deposits of Manchester and its Neighbourhood."—Manchester Literary and Philosophical Society's Memoirs, vol. viii.

REVIEWS.

I.—Volcanos: The Character of their Phenomena, their share in the structure and composition of the surface of the globe, and their relation to its internal forces, with a descriptive Catalogue of all known Volcanos and Volcanic Formations. By G. Poulett Scrope, F.R.S., F.G.S., etc., etc. Re-issue of the Second Edition with Prefatory Remarks, and a List of Recent Earthquakes and Eruptions. 8vo. pp. 538. London: 1872.

THE author of this grand work of reference, finding that a larger number of copies of the Second Edition (published in 1862) had been printed than were as yet disposed of, determined to preface the re-issue of the remaining copies with a short notice of the speculations put forward by various writers during the past ten years; and also to append a list of the most important earthquakes and eruptions of various degrees of intensity which have occurred in the districts habitually subject to similar occurrences.

On the subject of the "Assumed igneous fluidity of the interior of the Globe" Mr. Scrope remarks, "in the first place, that these speculations are based on *à priori* conjectures, not on any recorded facts, and belong moreover to the province of Astronomy rather than of Geology. Secondly (he says), I earnestly protest against the assertion of some writers, that the theory of the present internal fluidity of the globe is or ought to be generally accepted by geologists, on the evidence of its high internal temperature." Mr. Scrope proceeds to point out that the idea "that a molten interior to the globe underlies a thin superficial crust, its surface agitated by tidal waves, and flowing freely towards any issue that may here and there be opened for its outward escape," is an attractive and sensational one, but cannot be supported by reasoning based on any ascertained facts or phenomena. Mr. Scrope proceeds to express his opinion that we must give up the idea of a liquid interior to our earth, as unsound, and substitute therefor the theory of the existence of liquefied matter "in pockets or vescicles here and there at varying, but still moderate distances from the outer surface." "This view of the complete, or almost complete, solidity of the subcortical mass of the globe (he adds), is, I think, rendered still more probable when we consider the enormous *pressure* to which every portion of the heated interior must be subjected, not merely from the weight or contraction on cooling of the outer belt, but still more, perhaps, from the vast internal tension of its every part, owing to the tendency to expansion caused by its intense heat, and this whether that part be in a solid, fluid or gaseous state. More assuredly will this be the case if we suppose, as we reasonably may, that at least the first layers of matter immediately underlying the external crust consist of the same crystalline or granular mineral substances (chiefly felspathic silicates) which constitute the lowest known rocks, granitoidal or porphyritic, portions of which in every part of the globe are known to have forced their way upwards in a more or less liquefied state, and at an intense temperature, through the overlying stratified masses. These rocks are found on examination to contain a considerable quantity of water disseminated through them interstitially or in minute cavities; and it is obvious what an amount of internal elasticity or tension must be communicated to such a mass, at its certainly high temperature, by the tendency of these minute particles of water to expand into vapour."

The theory of pockets or cavities in the earth's crust filled with molten matter at an exceedingly high temperature, is, we believe, open to as grave difficulties as is the theory of a fluid interior. We think, however, it has rather been *assumed* that geologists do believe in a fluid interior with a moderately thick solid crust.

Mr. Scrope has himself clearly pointed out, that even highly liquid lava is, when ejected, rather of the condition of thick molasses (solidifying rapidly upon yielding up its molecules of steam), than of a freely-flowing liquid body.

Any molten matter, therefore, which may exist in the interior of the earth, is doubtless, under such pressure, that even this moderate degree of fluidity is impossible, save where that pressure is locally alleviated by earthquake movements and the opening up of fissures in the crust consequent thereon. How then could tidal movements take place?

The strongest argument to our mind in favour of a *common source* for all volcanic matter—we care not at what depth Sir William Thomson places it beneath the solid crust of the earth—is that brought forward by Mr. David Forbes, F.R.S. (see GEOL. MAG., 1868, Vol. V., p. 97), in reply to the views of Dr. T. Sterry Hunt, "That volcanic rocks taken from any quarter of the world, no matter how far distant from one another—from Iceland or Tierra del Fuego, from the Islands of the West Indies, or from those of Polynesia—that in all cases such rocks possess *an absolute identity* in chemical and mineralogical composition, in physical and optical properties: can any geologist be expected to believe that such rocks have been formed by the melting up of a mere mechanical aggregate of rock-débris, possessing no analogy whatsoever, and whose chemical composition, etc., is known to vary to the widest imaginable extremes."

The limits of our space preclude us from giving a more detailed notice of the valuable prefatory observations appended to this re-issue of Mr. Poulett-Scrope's "Volcanos"; a work which must always remain the standard book on this branch of geological investigation; but we hope in a future number to be able to refer again to some other points touched upon by the learned and accomplished author.

II.—RUDIMENTARY TREATISE ON GEOLOGY. [Partly based on Major-Gen. Portlock's Rudiments of Geology.] Part I.—Physical Geology. By RALPH TATE. 8vo., pp. 215. (Lockwood & Co. 1871.)

SINCE the first edition of Portlock's Treatise on Geology was published twenty years have elapsed. The work was very popular, and a third edition was published in 1854. In bringing out the present edition Mr. Tate tells us that it has been found necessary to re-write the work, and he has divided it into two parts, the one entitled "Historical Geology," a new and independent treatise; the other, which is now before us, entitled "Physical Geology," containing some portion of the letter-press and many of the illustrations of Portlock's work. Comparing this with our old volume of Portlock, the third edition, we find that great improvements have been made by additions and alterations, necessitated by the progress of geology, but there nevertheless remains so much of the original work that we are at a loss to understand why Mr. Tate did not in this volume adopt the more modest title of Editor rather than that of Author. We do not find fault with the book, but we think that sufficient justice has hardly been done to Major-General Portlock. Mr. Tate has made many additions to the physical part, while that section which relates to palæontology, the fossilization of plants and animals, and their geographical distribution, has received important modifications. We can recommend it as a useful introduction to the more advanced Manuals of Jukes and Geikie or Dana. For, as Jukes remarked many years ago, in the preface to his "Popular Physical Geology," there can hardly be too many elementary books which are the results, more or less completely, of actual experience, and not the mere compilation and compression of other books. Not because any of them would contain a large amount of matter not to be found in all the rest, but because, by the different order and arrangement of the different writers, the matter may be looked at on all sides and in every light. Thus we are glad to see this new edition of Portlock's useful little Treatise on Geology.

III.—Geological Survey of England.

We are happy to announce the publication of the new edition of Sheet 7 of the Geological Survey Map of England, showing all the Drift deposits, on the scale of one inch to a mile. For some time past we have been looking forward to the completion of this map, and we must now congratulate the Survey on this first issue of the Drift maps. A glance at the old edition, comparing it with this new one, shows at once the great utility of mapping all the superficial deposits, for not only have they a high economic value, but in their relations to drainage and health, an inquiry which we are glad to observe is attracting public attention, their importance cannot be over-estimated.

The area comprised in this sheet, about 800 square miles, includes the western part of London. It is bounded on the east by Hornsey and Enfield; on the north it takes in Hatfield Park, St. Albans, Hemel Hempstead, Great Berkhampstead, and Wendover; on the west it extends beyond Princes Risborough, Great Marlow, and Twyford in Berkshire; while to the south it includes Windsor and the Great Park, Staines, Twickenham, Wimbledon Park, and Dulwich.

The geology, originally surveyed and published in 1861, included the Gault, Upper Greensand, Chalk, Reading-beds, London-clay, Lower Bagshot-beds, the Thames-valley gravel and Alluvium. These were mapped by Messrs. H. Bauerman, W. Whitaker, T. R. Polwhele, and R. Trench. Some revision of this work has now been made by Messrs. H. W. Bristow and W. Whitaker.

The Drift deposits, which are the important features of this new map, are as follows:

Dry valley flint Gravel. Rainwash.
River Gravel and Brick-earth.
Clay-with-flints.
Brick-earth.
Boulder-clay } Glacial deposits.
Gravel and Sand }
Pebble Gravel.

These deposits have been mapped by Messrs. H. W. Bristow, W. Whitaker, H. B. Woodward, F. J. Bennett, W. A. E. Ussher, J. H. Blake, and C. E. Hawkins.

The general characters and positions of these deposits were indicated by Mr. Whitaker in his Memoir on the Geology of the country, published in 1864; but since this much has been done, and particularly by Mr. Searles Wood, jun., in the classification of the various drift deposits of the East of England.

Although in the list of deposits shown in Sheet 7 no very precise chronological system has been adopted, this could hardly be expected in the earlier drift maps, as, until a very large area has been gone over, such a system could not be arrived at.

It is not quite clear at present whether the "pebble gravel" be of a distinct age from the gravel and sand of the Glacial period, as Mr. Hughes would have it, in the neighbourhood of Hertford, or whether we may not regard it, as Mr. Wood does, as a portion of the Mid-Glacial series, owing its pebbly nature to local derivation from Eocene pebble-beds.

The brick-earths which cap the high ground near High Wycombe, Hampden, Chesham, and St. Albans, may be of different ages, some portions belonging apparently to Mid-Glacial series being associated with the gravel and sand, some associated with the clay-with-flints, being probably due to local denudation of the Tertiaries; some portions appear to overlie the Boulder-clay, and therefore to be of Post-Glacial age.

These theoretical questions, however, do not affect the value of the map, for whatever age be assigned to the several deposits, the boundary lines will not be affected, and these it is which give the map a permanent value.

We understand that a large geological map with London as a centre will shortly be published by the Geological Survey. This has long been a desideratum, and we doubt not that it will be appreciated, not only for the economic uses to which it may serve, but also as a guide to geological students and local observers, of which latter unfortunately there are but few in the country included in Sheet 7.

IV.—On the Connexion of Certain Phenomena with the Origin of Mineral Veins. By J. Arthur Phillips, F.C.S., M.Inst.C.E., etc. *Phil. Mag.*, Dec., 1871.

THE Certain Phenomena referred to by the author are the *Solfataras,* fissures giving off steam, which occur in most volcanic districts. The most remarkable are those known as the Steamboat Springs in the State of Nevada, where some of the crevices are over 1000 yards in length, and are often entirely filled with boiling water, containing various mineral salts in solution. In the course of time incrustations (sometimes to the thickness of several feet) are formed on each side of the fissures, composed chiefly of hydrated silver, but containing also oxides of iron and manganese, traces of copper, minute crystals of iron-pyrites, etc.

The author thinks that these phenomena tend to show that the Theory of Ascension, which teaches that veins are the result of deposits of mineral substances which have been introduced into fissures from below, is the most rational method in which to view this formation. For further corroboration he gives analyses of water issuing from lodes in some of the deeper Cornish mines which were found to hold mineral substances in solution.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—January 10, 1872.—Joseph Prestwich, Esq., F.R.S., President, in the Chair.—The following communications were read:—1. "On *Cyclostigma, Lepidodendron,* and *Knorria* from Kiltorkan." By Prof. Oswald Heer, F.C.G.S.

In this paper the author indicated the characters of certain fossils from the Yellow Sandstone of the South of Ireland, referred by him to the above genera, and mentioned in his paper "On the Carboniferous Flora of Bear Island," read before the Society on November 9th, 1870 (see Q. J. G. S., vol. xxvii., p. 1). He distinguished as species *Cyclostigma Kiltorkense,* Haughton, *C. minutum,* Haught., *Knorria acicularis,* Göpp. var. *Bailyana,* and *Lepidodendron Veltheimianum,* Sternb.

Discussion.—Mr. Carruthers was glad that he had made the observations which he did on Professor Heer's former paper, as it had caused the Professor to give the reasons on which his opinions were based. He was doubtful whether the success which had attended Professor Heer's determination of species from leaves justified the application of the same principles to mere stems. He could not accept the difference in size or distance of leaf-scars as a criterion of species, inasmuch as they were merely the result of the difference in the age and size of the parts of the plants on which they were observed. Even Professor Heer himself had united together specimens presenting greater differences in this respect than those which he distinguished. He considered *Cyclostigma Kiltorkense, C. minutum,* and *Lepidodendron Veltheimianum* to be founded on different parts of one species. In the Kiltorkan fossils the outer surface of the original stems was often broken up into small fragments, the phyllotaxy on which proved them to be portions of large stems, and not entire branches. As to *Knorria,* it was certainly the interior cast of the stem of *Lepidodendron,* with casts of the channels through which the vascular bundles passed with some cellular tissue to the leaves; and the specimen figured showed that it belonged to a branch similar to that represented as *C. minutum.* He considered that the four supposed species belonging to three genera were only different forms of the same plant.

2. "Notes on the Geology of the Plain of Marocco, and the Great Atlas." By George Maw, Esq., F.G.S. etc.

The author described first the characters presented by the coast of Marocco, and then the phenomena observed by him in his progress into the interior of the country and in the Atlas Chain. The oldest rocks observed were ranges of metamorphic rocks bounding the plain of Marocco, interbedded porphyrites and the porphyritic tuffs forming the backbone of the Atlas Chain, and the Mica-schists of Djeb Tezah in the Atlas. At many points in the lateral valleys of the Atlas almost vertical grey shales were crossed; the age of these was unknown. Above these comes a Red Sandstone and Limestone series, believed to be of Cretaceous age, and beds possibly of Miocene age, which occupied the valleys of the Atlas and covered the plain of Marocco, where vestiges of them remain in the form of tabular hills. The probable age of these beds was determined on the evidence of fossils. The author noticed the sequence of denuding and eruptive phenomena by which the arrangement and distribution of these rocks has been modified, and described the more recent changes resulting in the formation of enormous boulder-beds flanking the northern escarpment of the Atlas plateau, and of great moraines at the heads of the valleys of the Atlas, both of which he ascribed to glacial action. An elevation of the coast line of at least 70 feet was indicated by raised beaches of concrete sand at Mogador and elsewhere, and the author considered that a slight subsidence of the coast was now taking place. The surface of the plain of Marocco was described as covered with a tufaceous crust, probably due to the drawing up of water to the surface from the subjacent calcareous strata and the deposition from it of laminated carbonate of lime.

Discussion.—Mr. Ball, as an Alpine traveller who had also visited the Atlas in company with Dr. Hooker and Mr. Maw, offered a few remarks. The plane of Marocco was not, in his opinion, a level, but an inclined plane, rising gradually in height up to the foot of the mountain, so that the base of the boulder ridges was at some height above the level of the plain near Marocco. He did not think that the boulder deposits could be safely attributed to glaciers, but thought rather that they had been carried into and deposited in a shallow sea. He thought also that Mr. Maw had somewhat over-estimated the thickness of some of the boulder deposits; and though there was one instance of an undoubted moraine in one of the higher valleys of the Atlas, yet he could not agree in the view that the glaciation of the Atlas was general. He could not accept such a great thickness of beds as that represented by the vertical shales in Mr. Maw's section.

Prof. Ramsay was pleased that the author, though giving so many interesting details, had not assigned any definite age to many of the beds. He agreed with him as to the cause assigned for the great tufaceous coating of the country. He had already assigned the same cause for the existence of certain saline beds, and would attribute the existence of the great coating of gypsum at a slight depth below the surface of the Sahara to the same cause. As to the existence of moraines, he was not surprised to find them in the Atlas, as they were already known in the mountains of Granada. As to the escarpments, it was now well known that, as a rule, they assumed a direction approximately at right angles to the dip of the strata; and he felt inclined to consider that the bulk of the mounds at the foot of the escarpment of the Atlas were rather the remains of a long series of landslips from the face of the cliffs than to an accumulation of moraine matter.

Mr. D. Forbes commented on the similarity of the rocks to those of the Andes in South America. In the Andes the porphyritic tuffs appeared to belong to the Oolitic age; and the igneous rocks associated with them were of the same date. He thought that, so far as the author's observations had gone, the structure of the Atlas was much the same as that of the Andes.

Mr. W. W. Smyth mentioned that in the district to the east of the Sierra Nevada, in the south part of Spain, where there was great summer heat, and also heavy occasional rainfall, the same tufaceous coating as that observed in Marocco was to be found. He had been led to much the same conclusion as to its origin as that arrived at by Mr. Maw. The upper part was frequently brecciated, and the fragments re-cemented by carbonate of lime.

Mr. Seeley, though accepting Mr. Etheridge's determination as to the Cretaceous age of Mr. Maw's fossils if found in England, could not accept it as conclusive in the case of fossils from Marocco. The genus *Exogyra*, for instance, which ranges through the secondary to existing seas, might well belong to some other age; and even the fossils presumably Miocene might, after all, date from some other period.

Mr. Maw, in reply, stated that he agreed with Mr. Ball as to the rise in the Marocco plain as it approached the Atlas, having taken it in one direction at 400 feet in 25 miles. He pointed out the resemblance between the moraines in the valley of the Rhone and those which he regarded as such on the flanks of the Atlas. As a proof of their consisting of transported blocks, he mentioned the fact that the red sandstone rock of which they were composed did not occur in the adjacent escarpments, but was not to be found within seven or eight miles. There was, moreover, a mixture of different materials in the mounds.

II.—January 24, 1872.—Joseph Prestwich, Esq., F.R.S., President, in the Chair. The following communications were read:—1. "On the Foraminifera of the Family Rotalinæ (Carpenter) found in the Cretaceous Formations, with Notes on their Tertiary and Recent Representatives." By Prof. T. Rupert Jones, F.G.S., and W. K. Parker, Esq., F.R.S.

The authors enumerated the Rotalinæ which have been found in the Cretaceous rocks of Europe, and showed by tabular synopses the range of the species and notable varieties in the different formations of the Cretaceous system. For the comparison of the Tertiary Rotalinæ with those of the Cretaceous period the following Tertiary formations were selected:—The Kessenberg beds in the Northern Alps, the Paris Tertiaries, the London Clay, the Tertiary beds of the Vienna Basin, and the English and Antwerp Crags. The authors also enumerated the recent Foraminifera of the Atlantic Ocean.

The authors stated that of *Planorbulina* several species and important varieties of the compact, conical form occur throughout the Cretaceous series, and that those of the Nautiloid group are still more abundant. The plano-convex forms are represented throughout the series by *P.* (*Truncatulina*) *lobatula;* but the flat concentric growths had not yet come in. *Planorbulina* extends down to the Lias and Trias. *Pulvinulina repanda* is feebly represented in the uppermost Chalk, but forms of the "*Menardii*" group abound throughout the series. Species of the "*elegans*" group are peculiarly characteristic of the Gault, and some of the "*Schreibersii*" group are scattered throughout. These two groups extend far back in the Secondary period. The typical *Rotalia Beccarii* is not a Cretaceous form, but the nearly allied *R. umbilicata* is common. *Tinoporus* and *Patellina* occur at several stages; *Calcarina* only in the Upper Chalk.

The above-mentioned types are for the most part still living, but the "*auricula*" group of *Pulvinulina* is wanting in the Cretaceous series, as also are *Spirillina* and *Cymbalopora*, except that the latter occurs in the Maestricht Chalk. *Discorbina* and *Calcarina* make their first appearance in the uppermost Chalk. The chief distinction between the Cretaceous and the existing Rotalinæ was said to consist in the progressively increasing number of modifications. The authors concluded by disputing the propriety of regarding the Atlantic ooze as homologous with the Chalk.

Discussion.—The President suggested the possibility of some of the minute Foraminifera being transported fossils derived from earlier beds than those in which they are now found.

Dr. Carpenter observed that the mode of examination to be adopted with Foraminifera was different in character from that which was applicable to higher organisms. The range in variation was so great that an imperfect examination of Nummulites had sufficed to make M. d'Archiac reduce the number of species by one half; and all the speaker's subsequent studies had impressed upon him the variety in form and in sculpturing of surface on individuals of the same species. When out of some thousands of specimens of *Operculina*, say, a dozen pronounced forms had been selected, such as by themselves seemed well marked and distinct, it might turn out that after all there was but one species present with intermediate varieties connecting all these different forms. He thought the same held good with Rotalinæ, and that there were osculant forms which might connect, not only the species, but even the genera into which they had been subdivided. This fact had an important bearing on their genetic succession, especially as it appeared that some of the best-marked types were due to the conditions under which they lived. The temperature in tropical seas differed in accordance with the depth so much, that when 2000 fathoms were reached, a degree of cold was attained such as was to be found in high latitudes; and in consequence the deep-sea forms in tropical latitudes assumed the dwarfed character of those in shallower seas and nearer the Pole. He suggested caution in drawing inferences from forms so subject to modification, both spontaneous and due to the depth of the sea, especially as connected with abundance of food.

Prof. Ramsay remarked that geologists would be pleased to find Foraminifera exhibiting, like other organisms, changes in some degree connected with the lapse of time. These low forms, however, could hardly afford criteria for judging of the age of geological formations, while at the same time such ample means were afforded by the higher organisms for coming to a conclusion. He cited, for instance, the Cephalopoda, as proving how different were the more important forms of marine life in Cretaceous times from those of the present day. He thought that no one who had thoroughly studied the forms of ancient life would be led to ignore the differences they presented, as a whole, from those now existing.

Mr. Seeley, Dr. Murie, and Mr. Hicks also made some remarks on the paper.

Prof. Jones, in reply, observed that the question of whether the Foraminifera in a given bed were derived or not was to be solved partly by their condition and partly by their relative proportions, but that in most cases sufficient data existed on which to found a judgment. He agreed with Dr. Carpenter as to the existence of extreme modifications, and it had been his object to ignore such as seemed due to ordinary and local causes, and to group the forms in accordance with certain characteristics. Whether the classification was right or wrong, it was necessary, for the sake of increasing knowledge, that fossils of this kind should be arranged in groups; and whether these were to be regarded as truly generic was a minor consideration. In forming their types and subtypes the authors had carefully avoided minor differences; but they still thought that the modifications which were capable of being substantiated were significant of a great lapse of time. A variation once established never returned completely to the original type. In *Globigerina*, he stated that there were in Cretaceous times 8 forms, in Tertiary 12, at the present time 14; and these modifications he regarded as equivalent to the specific changes in higher animals.

2. "On the Infralias in Yorkshire." By the Rev. J. F. Blake, M.A., F.G.S.

The Infralias, *i.e.* the zones of *Ammonites planorbis* and *Am. angu-*

latus, have been recorded hitherto only from Redcar, to the beds at which place the author referred; but the chief object of the paper was to describe some sections at Cliff, near Market Weighton, where these and lower beds are well exposed, and have yielded a numerous suite of fossils. He considered, however, that these beds did not belong to the typical Yorkshire area, but were the thin end of the series which stretches across England. He supposed there had been a barrier in Carboniferous times, which had separated the coal-fields of Yorkshire and Durham, prevented the continuity of the Permian beds, and curved round the secondary rocks to the north of it, to form the real Yorkshire basin, while these beds at Cliff were immediately to the south of it.

The sections described were six in number, the first pit yielding the great majority of the fossils, and the third showing best the succession of the beds. The fossils could be mostly identified with known forms, and showed a striking similarity to the Hettangian fauna. In all the clays of the Infralias Foraminifera were numerous and varied.

The section in pit No. 3 showed, commencing at the top:—1. Stone bed with *Am. angulatus* (the fossiliferous bed of pit No. 1). 2. Thick clays, with bands of stone characterized by *Am. Johnstoni.* 3. One band of clay with *Am. planorbis.* 4. Thin-bedded stones and clays, some of them oyster-bands. 5. Clays without Foraminifera, and with impressions of *Anatina* (White Lias).

The *Avicula-contorta* series is not reached, nor are there any signs of the bone-bed, as the junction with the Keuper marls, which are found three miles off, is not seen.

The paper was followed by references to the fossils mentioned, including the description of those that are considered new.

Discussion.—Prof. Duncan remarked that English geologists had been backward in receiving the term Infralias, which he had suggested with respect to the Sutton Down beds some years ago, and the propriety of which was shown by the term having been applied to the same beds by French geologists at a still earlier period. As to the White Lias, he regarded it as a mere local deposit, not to be found out of England. He traced the existence of the Infralias from Luxembourg through France into South Wales, where Corals were abundant. In Yorkshire, though one fine Coral had been found, the Ammonites seemed to point to a difference in condition.

Mr. Hughes remarked that the lithological character of the beds, as described by the author, did not agree with that of the Infralias in the S.W. of England or the N. of Italy. That the palæontological evidence which had been laid before the Society did not confirm the view that they were Infralias, the author having especially noticed the absence of *Avicula contorta* where he expected that it should occur. Also, by reference to the author's section, Mr. Hughes pointed out that below what he described as Infralias he drew other beds which were not Trias, the author having explained that some beds which had been called Trias were only stained beds of Liassic age.

The Rev. J. F. Blake, in reply, acknowledged the difference between the Yorkshire section and those of the neighbourhood of Bath, but insisted on the similarity of the fossils.

III.—February 7, 1872.—Joseph Prestwich, Esq., F.R.S., President, in the Chair.—The following communications were read:—1. "Further Notes on the Geology of the neighbourhood of Malaga." By M. D. M. d'Orueta. Communicated by the President.

In this paper, which is a continuation of a former note laid before the Society (see Quart. Journ. Geol. Soc., xxvii., p. 109), the author commenced by stating that his former opinion as to the Jurassic age of the rocks of Antequera is fully borne out by later researches upon their fossils. They apparently belong to the Portlandian series. The author made considerable additions to his description of the Torcal, near the foot of which he has found a sandstone containing abundance of *Gryphæa virgula* and *Ostrea deltoidea*. This he regards as equivalent to the Kimmeridge Clay. In the Torcal he has also found a soft, white, calcareous deposit, overlying the limestones of supposed Portlandian age, and containing a fossil which he identifies with the Tithonian *Terebratula diphya*. The author discussed the peculiar forms assumed by the rocks of the Torcal under denudation, which he supposed to be due originally to the upheaval caused by the rising of a great mass of greenstone, portions of which are visible at the surface on both sides of the range.

2. "On the River-courses of England and Wales." By Prof. A. C. Ramsay, LL.D., F.R.S., F.G.S.

The author commenced by describing the changes in the physical conformation of Britain during the Jurassic and Cretaceous periods, and the relations which the deposits found during those periods bore to the Palæozoic rocks of Wales and the north-west of England. He stated that the Miocene period of Europe was essentially a continental one, and that it was closed by important disturbances of strata in central Europe, one effect of which would be to give the Secondary formations of France and Britain a slight tilt towards the north-west. To this he ascribed the north-westerly direction of many of the rivers of France; and he surmised that at this period the rivers of the middle and south of England also took a westerly course. The westerly slope of the Cretaceous strata of England was also, he considered, the cause of the southern flow of the Severn, between the hilly land of Wales and the long slope of chalk rising towards the east. The Severn would thus establish the commencement of the escarpment of the Chalk, which has since receded far eastward.

The author believed that after the Severn had cut out its valley the Cretaceous and other strata were gradually tilted eastwards, causing the easterly course of the Thames and other rivers of southern and eastern England. In these and other cases adduced by the author, the sources of these rivers were originally upon the Chalk near its escarpment and it is by the recession of the latter (which was followed by the formation of the Oolitic escarpment) that its present relation to the river-courses has been brought about. The author also referred to the courses followed by the rivers of the more northern part of England, and indicated their relations to the general dip of the strata.

Discussion.—Mr. Hughes pointed out that in Wales and the Lake-district, which in this question might be considered as one, there were two plains of marine denudation, the one referred to by Prof. Ramsay averaging a little over 2000 feet, and the other about 3000 feet above the sea. Such plains get eaten back and cut up into valleys, but their general level does not get much lowered by subaerial denudation. Therefore, in considering the western drainage area of the ancient Severn, it was important to fix the age of these plains. He did not agree with Prof. Ramsay that the 2000 feet plain was pre-Carboniferous, as the Carboniferous and Old Red hills of S. Wales and, in a more marked way, those of West Yorkshire and the Lake-district were evidently cut down by the same denudation that planed off the top of the Silurian area, and their tops formed part of the same plain. He did not think that this plain could be even pre-Oolitic; for the shingle beach of the Trias, which might be considered as the basement-bed of the Oolitic series, was evidently formed round the margin of that old land, whereas had this plain existed there would not have been land sufficiently high to have arrested the Oolitic sea during the period of greatest submergence; and a conglomerate implies a near shore. The absence of a coarse shore-deposit at the base and the character of the Cretaceous deposits also would lead him to infer that the Chalk-sea probably washed no land so near as Wales; but it was quite possible that the chalk was removed from the Welsh area when the 2000-feet plain was formed; and so we should refer the initial Severn to the time when the deposits of the sea that formed that plain were being eaten back, and not to the time when the Chalk was being removed. He asked where were the Chalk valleys when the drainage of the eastern area ran west into the Severn, as there was considerable difficulty in supposing that the main westerly drainage was along the same lines as that of the modern easterly streams. He pointed out that the great W.N.W. disturbances—many, if not all, of which were in part Post-tertiary—must be taken into account in this inquiry; *e.g.*, the synclinal of central Devon running into the English Channel near the Isle of Wight; the anticlinal of the Bristol Channel and the Weald, which we know was a barrier in pre-Carboniferous times, from the different character of the Coal-measures of Wales and Culm-measures of Devon; Mr. Godwin-Austen's ridge bringing up the old rocks under London; the barriers which caused the Lower and Upper Silurian of S. Wales to differ so much from those of N. Wales and the Lake-district, and were the indirect cause of the bosses of Silurian rocks which project through the newer rocks in Central England; the barriers that divided the northern coal-fields; the Craven Faults and the great valley which runs along them,—these and many others have obviously affected recent denudation. A slight tilt to the west would send the drainage again to the west along some of them; and the question involved the consideration of all traces of such changes of level.

Prof. Duncan observed that one important point in the paper was the hypothetical dip of the Chalk, on which the existence of the Severn was made to depend; and commented on the denudations which must have taken place during the Glacial and Pliocene period. He differed from the author in his view of the character of the Oolitic period, which he regarded as one of great oscillation. As to the amount of Palæozoic land-surface in Cretaceous times, he maintained that the purity of the Chalk deposits and their freedom from any terrestrial waste bore evidence of the distance of the land at that time. The depth of the sea in which they were formed was immense; and in the Upper Cretaceous period the oscillations were also great. He disputed the fact of the Miocene period of Europe having been continental in character, especially as regards the upper and middle parts of the deposits, in which Corals abundantly occurred. The elevation of the Alps was, he maintained, of a slow progressive character, which could hardly have effected so great an area as supposed by Prof. Ramsay.

Mr. Evans called attention to the relation of the present flow of many rivers to the last elevation of the land at the close of the Glacial period. The deposits of the Severn valley, he thought, proved its preglacial origin, and consequently supported Prof. Ramsay's argument; but the condition of the land at the close of the Glacial period was also to be fully taken into consideration, as the previously existing channels had in many instances been obliterated during that period. To a great extent Mr. Evans agreed with Prof. Ramsay, but he would wish to see the explanation carried down to a later date.

Mr. Green remarked, in illustration of the retrogression of escarpments, that he had had some opportunity of observing the process while still in progress. In the Carboniferous rocks of the north of England, where the dip of some hard rock was in a certain direction and it was overlain by softer strata, it was constantly the case that a brook ran along the line of junction, undermining the softer beds, bringing them down into the stream, and then removing them. It was thus that escarpments receded.

Prof. Morris remarked that at an early period the Alps on the south, and the Cumberland mountains on the north, formed the boundaries of a sort of trough, and that this to some extent must have influenced the flow of the rivers both in Britain and on the Continent. He considered that the series of elevations in pre-Permian times had also much to do with the configuration of some parts of the country, and therefore of its river-basins. The evidence of the Oolite series was that it was deposited in an area of gradual depression, which was subsequently again elevated; and there was no doubt of the existence of a large amount of land over a great part of central England during the deposition of some of the later Oolitic beds. Then again came a depression during the period of the White Chalk. With regard to the Severn valley, he recalled the observations of Sir H. de la Beche as to its having been an ancient marine channel, connecting the estuary of the Ribble and what is now the Bristol Channel. He cited Prof. Phillips to account for the presence of the Lecky quartz pebbles in the valley of the Thames by the existence of ancient lochs in the Glacial sea.

Mr. Whitaker remarked on the probable extension of the Chalk as far as the Scilly Islands, which was evinced by the flints there found on the surface. He attributed the fact of so many of the streams breaking throught the Chalk escarpment on the south and so few on the north, to the difference of the dip in the two cases.

The President could not give in his adhesion to Prof. Ramsay's opinion. To establish so general a view as that propounded, he thought that a more extensive array of facts with regard to the conditions of the river-valleys should have been adduced. He wished for evidence as to the existence of old river-gravels at a greater elevation above the present river Severn, for instance, than that afforded by the author. The elevation of the Alps he regarded as not sufficient to account for the lines of drainage in Britain. It was to be borne in mind that during the Quaternary period the excavatory force of the rivers was much greater than at the present day. He thought there was still much to be learnt as to the causes which led to the direction and extent of the present river-valleys, the original rudiments of which were probably due to other causes than river-action.

Prof. Ramsay, in reply, was inclined to restrict himself to the immediate subject of his paper. With regard to the so-called Straits of Malvern, he accepted the view so far as it assumed that an ancient river-valley had, by submergence, been converted into a strait. He had purposely omitted in his paper all consideration of the Glacial period, for the simple reason that the initial direction of the river-valleys had been given in Preglacial times. His object was merely to show the causes of the initial direction of the rivers; and he could not be expected, in a paper before the Geological Society, to take these minor points into serious consideration. The Trias he had always regarded as a great freshwater deposit, which of course involved such terrestrial conditions as those which had been pointed out. He could not agree that some intercalations of marine beds destroyed the generally continental character of the Miocene beds of the northern half of Europe. He repudiated the idea of an immediate connexion between the elevation of the Alps and the flow of the Severn, though such a general tilting of the strata as that of which the last elevation of the Alps was one of the principal results, produced its effects upon a wide area in western Europe. The volume of the rivers in former times had nothing to do with his subject; but the cutting back through escarpments was, he thought, best explained in the manner he had suggested.

IV.—Annual General Meeting, February 16th, 1872.—Joseph Prestwich, Esq., F.R.S., President, in the Chair.

The Secretary read the Reports of the Council, of the Library and Museum Committee, and of the Auditors. The general position of the Society was described as satisfactory, although, owing to the number of deaths which had taken place among the Fellows during the year 1871, the Society did not show the same increase which has characterized former years.

In presenting the Wollaston Gold Medal to David Forbes, Esq., F.R.S., Sec. G.S., for transmission to Prof. Dana, of Yale College, Connecticut, the President spoke as follows:—

Mr. Forbes,—I have the pleasure to announce that the Wollaston Medal has been conferred on Prof. Dana, of Yale College, Newhaven, U.S.; and in handing it to you, in the absence of our Foreign Secretary, Prof. Ansted, for transmission to our Foreign Member, I beg to express the great gratification it affords me that the award of the Council has fallen on so distinguished and veteran a geologist.

Prof. Dana's works have a world-wide reputation. Few branches of geology but have received his attention. An able naturalist and a skilful mineralogist, he has studied our science with advantages of which few of us can boast. His contributions to our science embrace cosmical questions of primary importance—palæontological questions of special interest—recent phenomena in their bearings on geology, and mineralogical investigations so essential to the right study of rocks, especially of volcanic phenomena. This wide range of knowledge he brought to bear in the production of his excellent Treatise on Geology, one of the best of our class books, embracing the elements as well as the principles of Geology. His Treatise on Mineralogy exhibits a like skill in arrangement and knowledge in selection. In conveying this testimonial of the high estimation in which we hold his researches to Prof. Dana, may I beg also that it may be accompanied by an expression of how strongly we feel that the bonds of friendship and brotherhood are connected amongst all civilized nations of the world by the one common, the one universal, and the one kindred pursuit of truth in the various branches of science, before which special nationality is lost in that general nationality which groups all things and all men under one banner in the study of God's works!

Mr. David Forbes, in reply, said that it was to him a great pleasure to have, in the name of Prof. Dana, to return thanks to the Society for their highest honour, and for this mark of the appreciation in which his labours are held in England. It had rarely if ever occurred in the history of the Society that the Wollaston Medal had been awarded to any geologist who had made himself so well known in such widely different departments of the science; for not only was Prof. Dana pre-eminent as a mineralogist, but his numerous memoirs on the Crustaceans, Zoophytes, coral islands, volcanic formations, and other allied subjects, as well as his admirable treatise on general Geology, fully testify to the extensive range and great depth of his scientific researches.

At a moment when political troubles threaten the amicable relations so long existent between the two countries, it was a further source of gratification to see, in this award of the Council, not only a token of scientific amity, but also a proof that in science at least no other considerations than those of true merit are allowed to sway.

The President then presented the Balance of the Proceeds of the Wollaston Donation-fund to Prof. Ramsay, F.R.S., F.G.S., for transmission to James Croll, Esq., and addressed him as follows:—

Prof. Ramsay.—The Wollaston Fund has been awarded to Mr. James Croll, of Edinburgh, for his many valuable researches on the glacial phenomena of Scotland, and to aid in the prosecution of the same. Mr. Croll is also well known to all of us by his investigation of oceanic currents and their bearings on geological questions, and of many questions of great theoretical interest connected with some of the great problems in Geology. Will you, Prof. Ramsay, in handing this token of the interest with which we follow his researches, inform Mr. Croll of the additional value his labours have in our estimation, from the difficulties under which they have been pursued, and the limited time and opportunities he has had at his command.

Prof. Ramsay thanked the President and Council in the name of Mr. Croll for the honour bestowed on him. He remarked that Mr. Croll's merits as an original thinker are of a very high kind; and that he is all the more deserving of this honour from the circumstance that he has risen to have a well-recognized place among men of science without any of the advantages of early scientific training; and the position he now occupies has been won by his own unassisted exertions.

The President then proceeded to read his Aniversary Address, in which he discussed the bearings upon theoretical Geology of the results obtained by the Royal Commission on Water-Supply and the Royal Coal Commission. The Address was prefaced by biographical notices of deceased Fellows, including Sir Roderick I. Murchison, Mr. William Lonsdale, Sir Thomas Acland, Sir John Herschel, Mr. George Grote, Mr. Robert Chambers, Mr. C. B. Rose, and M. Lartet.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*President:* The Duke of Argyll, K.T., D.C.L., F.R.S. *Vice-Presidents:* Prof. P. Martin Duncan, M.B., F.R.S.; Prof. A. C. Ramsay, LL.D., F.R.S.; Warington W. Smyth, Esq., M.A., F.R.S.; Prof. John Morris. *Secretaries:* John Evans, Esq., F.R.S.; David Forbes, Esq., F.R.S. *Foreign Secretary:* Prof. D. T. Ansted, M.A., F.R.S. *Treasurer:* J. Gwyn Jeffreys, Esq., F.R.S. *Council:* Prof. D. T. Ansted, M.A., F.R.S.; The Duke of Argyll, K.T., D.C.L., F.R.S.; William Carruthers, Esq., F.R.S.; W. Boyd Dawkins, Esq., M.A., F.R.S.; Prof. P. Martin Duncan, M.B., F.R.S.; R. Etheridge, Esq., F.R.S.; John Evans, Esq., F.R.S., F.S.A.; James Fergusson, Esq., F.R.S.; J. Wickham Flower, Esq.; David Forbes, Esq., F.R.S.; Capt. Douglas Galton, C.B., F.R.S.; Rev. John Gunn, M.A.; J. Whitaker Hulke, Esq., F.R.S.; J. Gwyn Jeffreys, Esq., F.R.S.; Sir Charles Lyell, Bart., D.C.L., F.R.S.; C. J. A. Meyer, Esq.; Prof. John Morris; Joseph Prestwich, Esq., F.R.S.; Prof. A. C. Ramsay, LL.D., F.R.S.; R. H. Scott, Esq., M.A., F.R.S.; Warington W. Smyth, Esq., M.A., F.R.S.; Prof. J. Tennant, F.C.S.; Henry Woodward, Esq., F.Z.S.

Geologists' Association.—A special general meeting was held on the 2nd February, when a revised code of laws was adopted. Subsequently, at the annual meeting, the report for 1871 was adopted, and the officers for the ensuing year elected.—At the ordinary meeting, which followed, the Rev. T. Wiltshire, M.A., F.G.S. etc., President, in the Chair, a paper was read by T. G. Bonney, M.A., F.G.S., Tutor of St. John's College, Cambridge, "On the Chloritic Marl or Upper Greensand of the neighbourhood of Cambridge."—The author commenced by a brief sketch of the geology of the Cam Valley, and the position of the seam, barely a foot in thickness, which rests upon the eroded surface of the Gault, and is full of green grains, and dark nodules, rich in phosphate of lime. He described the matrix as a fine chalky marl, full of Foraminifera, and minute fragments of organisms, with a considerable mixture of mud, insoluble in hydrochloric acid. The composition of the green grains (commonly called Glauconite) was then discussed, and it was shown that they differed considerably from the typical mineral of that name; he had not satisfied himself that any were casts of Foraminifera. After a few words on the phosphatic nodules and some erratic rocks in the bed, he gave a sketch of the palæontology of the deposits; calling attention to the condition of the various fossil remains, and to the number and size of the Pterodactyles and Turtles. He then gave his reasons for considering this deposit as formed during the Upper Greensand Epoch, but as containing many fossils which had been derived from the Upper Gault by slow denudation. The nodules he considered as mainly of concretionary origin; for they were too pure to be regarded as clay saturated by phosphate. He concluded by sketching out his conception of the physical geography of the East Anglian district in the Neocomian and lower part of the Cretaceous epoch.—Professor Morris, after some remarks on the value of the paper, spoke of the composition of the green grains, and then traced the range of the deposit, which he agreed with Mr. Bonney in thinking was the formation of a very long period of time.—Mr. Lobley remarked upon the mineralogical and palæontological differences existing between the Cambridge deposit and the Chloritic Marl of Dorsetshire.—Mr. Bonney, in his reply, having referred to the great scarcity of fossils in the Gault of Cambridge, the Rev. T. Wiltshire stated that the Gault of Kent was in some places devoid of organisms.—At the next meeting of the Association, Friday, 1st March, a paper will be read "On the Geology of Hampstead, Middlesex," by Caleb Evans, Esq., F.G.S.

CORRESPONDENCE.

NEW BRITISH CRUSTACEAN.

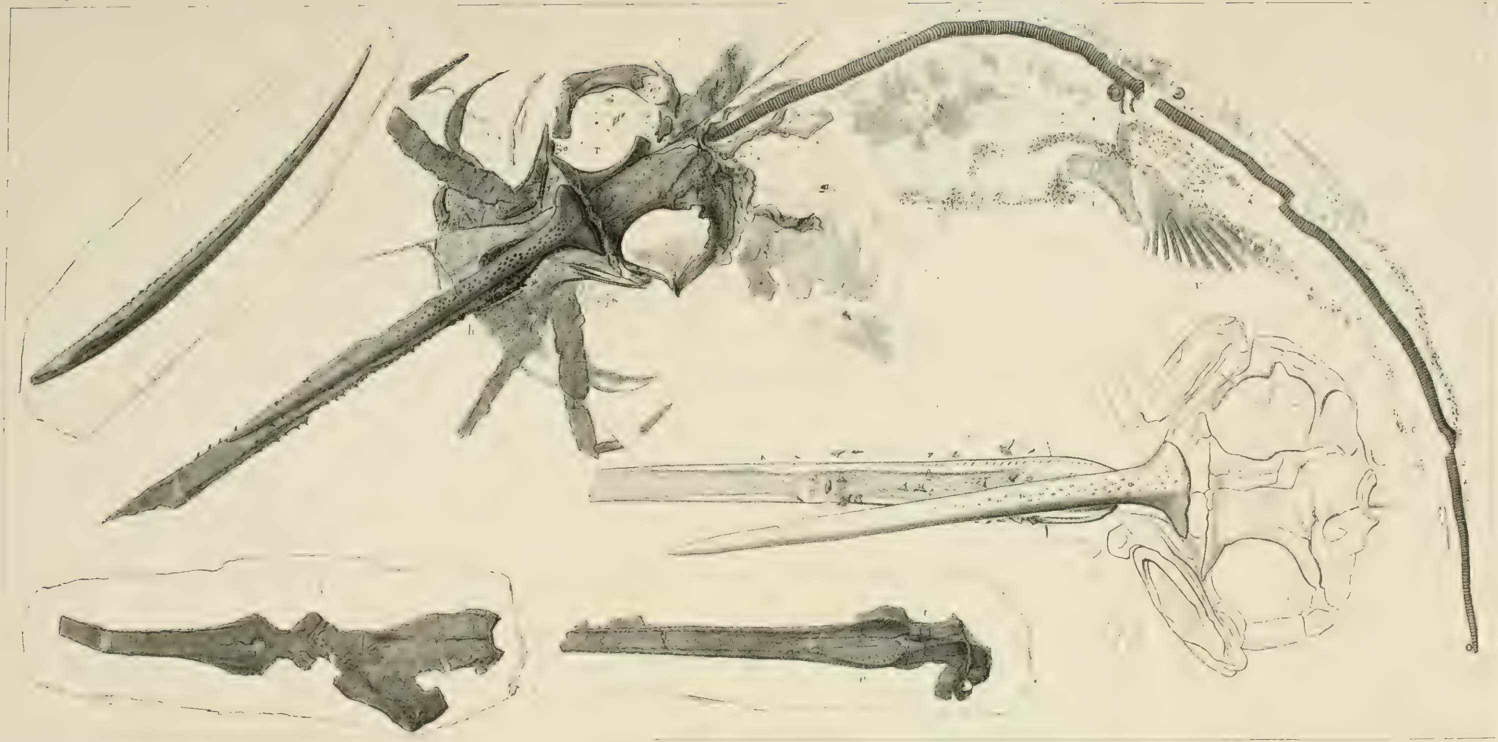
Sir,—Will you allow me to record the occurrence of *Gastrosacus Wetzleri*, which I have found in the so-called Coral Rag of Upware, Cambridgeshire. This, the only species of its genus, is found in the White Jura of Bavaria, and has not hitherto been met with in Britain.

St. John's College, Cambridge, W. Johnson Sollas.
27*th December*, 1871.

CALCAREOUSLY-INCRUSTED STONES IN DRIFT.

Sir,—As your obliging statement, at the close of my last article, relative to the inorganic origin of incrustations on stones found in the Upper Boulder-clay of Cheshire, might by some readers be regarded as bearing on the general arguments contained in the article, would you allow me to say that my reference to these stones (on which I did not venture to express a *decided* opinion) was extraneous to the main subject of the article, and that my object in making it was not to prove the marine origin of the Upper-clay (which is now admitted by all geologists), but to try to discover some resemblance between this clay and the brick-clay of Scotland, in which, in some places, organically-incrusted stones are common, according to Mr. Jamieson. I hope Mr. James Geikie will soon be able to correlate the Scotch and English drifts. I have no doubt that my *Pinel* is the equivalent of his *Till*.

D. Mackintosh.



J.L. Griesbach del et lith

Squaloraia polyspondyla *Agassiz*

THE

GEOLOGICAL MAGAZINE.

No. XCIV.—APRIL, 1872.

ORIGINAL ARTICLES.

I.—On the Rostral Prolongations of *Squaloraia polyspondyla*, Ag.

By William Davies,

Of the British Museum.

(PLATE IV.)

FEW amongst the many remains of Fossil Fishes hitherto discovered have excited more interest than the remarkable fossil Ray, found about forty years ago by Miss Anning in the Lower Lias at Lyme Regis.

This specimen, which is preserved in the Bristol Institution, was first described by Dr. Riley, who says, "The form of this animal is so striking and peculiar, that the majority of observers have disagreed not only as to its genus, but even as to its class; for by the generality it has been pronounced a Saurian."[1]

However, he rightly determined its zoological position, and pointed to its affinity with the Rays in most of its characters, and to the true Sharks in some others. Hence his generic name of *Squaloraia*.

Prof. Agassiz subsequently examined the specimen, and gave a description of it, illustrated by two fine plates, in his great work on Fossil Fishes.[2] He there corrects the error which Dr. Riley had made in supposing that the prolongations in front of the head were the jaws of the animal, whereas they formed but a snout analogous to that of the genus *Pristiophorus*. Agassiz adopts Dr. Riley's name for the genus, instead of that of *Spinacorhinus*, which he had previously proposed for it.

Another fine example of this interesting fossil fish (Pl. IV. Fig. 1), also from the Lias of Lyme Regis, has just been secured for the National Collection through the interest of Sir Philip Egerton, one of the Trustees, and the Earl of Enniskillen, which has served to throw some light upon what was previously obscure as to the true nature of the terminal prolongations of the head. As the object of this paper is solely to direct attention to these "prolongations," it may be advisable to reproduce here all that has been advanced in

[1] Geol. Trans., 2nd ser., vol. v., p. 83.

[2] Rech. Poiss. Foss., tom. iii., p. 384, tab. 42, 43.

regard to them in the respective descriptions of the before-named authors.

Dr. Riley observes, that "in front of the 'fontanelle' are two terminal prolongations. The superior has been fractured at its posterior extremity, and thrust backwards as far as the anterior edge of the orbits. It is elongated, conical, flattened posteriorly and superiorly, but becomes more rounded towards its anterior extremity. Firmly attached to its superior surface are many of the small spines already noticed. In its displacement it has been moved obliquely backwards, so that we are able to observe the superior surface of the inferior prolongation.

"This prolongation is likewise elongated and conical; its length was probably greater than the preceding, for its anterior extremity is broken, and has been lost. The superior surface, instead of being convex like the former, has a very wide and superficial groove, the boundaries of which are the edges on each side, elevated into a corresponding ridge.

"These ridges are higher and wider posteriorly than anteriorly.

"The form of these terminal cartilages in the *Rhinobatus* is, in their essentials, like that of our specimen."[1]

Agassiz says, "That the great prolongation of the anterior part of the head is not formed by the jaws, as Dr. Riley thinks; it is a beak (*bec*) similar to that of the *Scies* (*Pristis*), or rather analogous to the beak of the genus *Pristiophorus* of MM. Müller and Henle. It is composed of two parts, the lower and larger one depressed along the centre in such a way as to be able to receive the other, which is rounded. Around the beak one sees small spines similar to the 'boucles' of the Rays."[2]

From the foregoing extracts it is evident that both Prof. Agassiz and Dr. Riley considered that these two "prolongations" formed one beak or snout, the upper united at the "depression along the centre" to the lower. Examples in the National Collection show that they were not thus united, but that they really formed two unconnected processes.

Upon a close examination and study of the head of the new acquisition, I was impressed with the spine-like appearance and structure of the upper "prolongation," and, also, although it now rests—but somewhat obliquely—upon the inferior, that it was originally free or detached from it for the larger portion, if not along its entire length; and that this inferior "prolongation" has all that portion which is exposed of the upper surface covered with the dermal integument, which integument is also continuous beneath the upper "prolongation." This superior process is bare, with the exception of the radiated tubercles upon its upper surface, which show that it was a true external surface, and not covered by the skin. Referring to Agassiz's engraving of the specimen in the Bristol Institution, and which appears to have been carefully and accurately drawn, (the head of which has been reproduced by Mr. Griesbach upon the accompanying Plate IV., Fig. 5, from Agassiz's Poissons

[1] Geol. Trans., 2nd ser., vol. v., p. 84.
[2] Rech. Poiss. Foss., tom. iii., p. 379.

Fossiles, tab. 42.), I found these characters even more marked; for in that specimen, as observed by Dr. Riley, the upper process does not lie upon the lower, and this is clearly represented as being wholly covered by the skin. The upper is also shown as having more of a bony or spine-like structure. In both examples the position of the spine is the same; each has the expanded proximal end, and the same general form.

This close agreement in these most important points I thought sufficient to prove the upper process to be a true spine, articulated to the head by the expanded posterior end, and that the line of separation is not a fracture, as Dr. Riley considered it to be, but a true articular end or basal joint. Also, that the spine is not (as supposed by him) "thrust backwards," but occupies its normal position upon the head.

Nevertheless, other evidence was desirable to confirm and satisfactorily establish these conclusions; and this evidence was fortunately at hand. Among some unnamed and undetermined portions of fish remains from the Lias of Lyme in the Museum were three specimens which afforded the confirmation required. The most important of these is an "inferior prolongation" or snout (Pl. IV., Fig. 2). The specimen is $4\frac{1}{2}$ inches long, rather more than four-fifths being covered with the dermal integument, the anterior extremity is not present, the inferior surface is embedded in the matrix, whilst the upper is exposed and well preserved. At the proximal end is a low transverse ridge, which, if entire, would have been about three-fourths of an inch long, unfortunately only the left half is preserved: the front is slightly rounded, forming a facet to which the spine was articulated. This ridge is entire, and well marked on the perfect example (Pl. IV., Fig. 1 *r.*), its position being on a line with the anterior edges of the orbits. Extending from this ridge to the broad proximal end of the snout is a cartilaginous interspace of an inch in length, narrowest in the middle, and expanding by a gentle curve towards each end; it is bare, and has a rather coarse fibrous structure probably for the attachment of the muscular tissue which connected it with and served to elevate the spine above (Pl. IV., Fig. 2 *i.*). On the posterior half of this interspace, which is the nasal continuation of the cranial cartilage, is a short median crest at right angles to the transverse ridge already mentioned, and in junction with it; it divides about the middle of the interspace, and ultimately forms the two long cartilaginous processes which together form the snout, similar to that of *Rhinobatus*. These are round on their upper surface, but have a thin keel on their inner or opposing sides; that they are not connected by cartilage is shown where portions of the upper skin have been displaced, for we there see that the dermal layers are actually in contact. Anteriorly these processes are nearly uniform in height and thickness, until they approach the proximal end, where they curve gently outwards, rising into two lateral ridges, which again contract as they curve downwards and inwards, and terminate on either side of the interspace (Fig. 2 *e.*). The skin which covers the snout commences on the inside of these ridges, and is there coarsely rugose.

The next specimen to be noticed is a detached rostral spine (Pl. IV., Fig. 3). It is five inches long, and lies on its side in the matrix: the lateral expansions of the posterior end, and consequently the articulating surfaces, are destroyed; otherwise it is well preserved. The posterior half is straight, the anterior half rises upwards by a gentle curve to the apex. I assume this to be the normal form of the spine; if so, it is important, as proving that it could not have been united to the straight snout; and also, that the examples which are in place on the head (Pl. IV., Figs. 1 and 5) have been straightened by vertical pressure. On either side is a groove, which extends from the base nearly to the anterior end; probably a vascular canal. The inferior surface is slightly rounded, excepting a small portion of the proximal end, which is flat or very shallowly depressed. It is well ossified, and has the radiated tubercles isolated and irregularly disposed upon its upper surface, most numerous at the posterior end, whence they become more sparse, and also smaller, until they finally disappear at a short distance from the apex.

The position of this spine on a Plagiostomous fish was anomalous, and the purpose to which it could be applied difficult to determine, as I knew of no analogue among this order of fishes. For although its form and structure might suggest its having been an organ of defence, yet the position upon the head, and its manner of attachment, which could only allow of its elevation at a low angle, and therefore but little above the plane of the lower and longer snout, would preclude its having been applied to such use. I determined therefore to submit the specimens, and the views I had arrived at respecting them, to Dr. A. Günther, F.R.S., of the Zoological Department, British Museum. After careful examination he confirmed my conclusions, and added that the analogue was to be found in the *Chimæridæ;* and, moreover, that the specimens were the remains of males, and that in all probability, sooner or later, the female would be found. This valuable suggestion, for which I am much indebted to Dr. Günther, cleared up a difficulty I had experienced in placing the third of the before-mentioned specimens with the present genus (see Pl. IV., Fig. 4); for although it has the general form and character of the head of *Squaloraia,* it has no indication of ever having possessed a spine, as there is no transverse suture, nor ridge for its articulation; and the part corresponding to the interspace in the male *is covered by the skin,* which is unbroken from the occipital region to the end of what remains of the snout; this is imperfect, the anterior extremity, as in all the other specimens that have come under my notice, being absent. The cartilaginous processes which form its boundaries are extremely slender, mere threads, possibly suggestive of considerable flexibility; and the snout (judging from what remains of it) is, relatively to the head, much smaller than in the male. A considerable portion of the cranial cartilage is preserved, and also a part of the left orbit. The entire length is $4\frac{1}{2}$ inches; from the occiput to the expanded portion of the snout it measures 2⅝ inches, the snout being 2⅛ inches long. Dr. Günther considered this specimen to be most probably the remains of the head of the female.

That the dermal integument was extended on either side from the head to the anterior extremity of the snout, so as to form a conical beak or "cutwater," as in *Rhinobatus*, is evidenced by portions of the skin being preserved in front of the head (Fig. 1), and also a small portion on the detached snout. As we have already observed, the rostral cartilages are much more robust in the male than in the female; and especially that there is in that of the former a deep depression at the posterior end for the reception of the spine.

It is obvious from these characters that the snout was capable of offering a considerable amount of resistance to the spine, assuming that the functions of the latter subserved the same purpose as its analogue on the head of the *Chimæridæ;* a feasible assumption, from the fact that there are no indications of the powerful claspers that are possessed by the males of most species of the Rays, neither in the Bristol specimen, as noticed by Dr. Riley, nor upon that in the British Museum; and, also, that there are attached to the cartilaginous processes, on either side of the snout, a number of tubercles with recurved hooklets; and, moreover, that similar tubercles line the inner sides of the hollow formed by the ridges at its base (Fig. 1 *h.*). The spine has also three or four of these hooked tubercles adhering to its sides; they were probably more numerous originally, but have become detached by maceration. This armature was as well adapted for the firm retention of the female as the analogous hooklets of the rostral claspers of the *Chimæridæ*.[1]

But whatever the functions, the possession of this rostral spine is a peculiar feature, at present utterly unknown as occurring, even in a rudimentary form, in any other recent or extinct Shark or Ray. And it may ultimately prove to be of more than generic distinction among the *Raiidæ*.

The short and numerous vertebræ are also characteristic. In the Bristol specimen the vertebral column is imperfect; nevertheless, Dr. Riley counted 260 vertebræ, which he thus apportioned: cervical 28, dorsal 143, caudal 90. That in the British Museum has the spinal column nearly entire, only the extreme end of the tail is missing. It is 12 inches long, and has 370 vertebræ; they cannot be apportioned with certainty on account of the absence of the transverse elements of the scapular arch, but there are about 150 between the occiput and the pelvis; not quite so many as Dr. Riley assigns to the cervical and dorsal regions. Near the lumbar region of the back, where the vertebræ appear to be the largest, there are 31 in the length of one inch, and 35 in the same space in the tail, so that when entire the number probably exceeded 400. This specimen is in some respects

[1] It is an interesting fact in connexion with our subject, that *Squaloraia* and a *Chimæroid* species (*Ischyodus orthorhinus*, Egert.), in which this organ attained its maximum development, were contemporaries, both being found in the same Lias deposit at Lyme Regis. See a Paper on a "New Chimæroid Fish," by Sir Philip Egerton, Quart. Journ. Geol. Soc, vol. xxvii., p. 275, pl. xiii.

superior to the type example at Bristol, notably in the more perfect condition of the vertebral column; the jaws, covered with pits for the attachment of numerous and minute teeth, are present; they commence a little in front of the outer edge of the orbits, have a slight forward bend, and probably meet beneath the snout at the distance of half an inch from the transverse ridge; none of the teeth are present. The lateral nasal cartilages, connecting the head with the pectoral fins, are well conserved, but of these fins there are no remains;[1] a part of the left ventral fin joined to the pelvic girdle is however present (Pl. IV., Fig. 1 *v.*). Its entire length is 19 inches, the head and snout together measuring 7 inches.

In conclusion, I would suggest that possessors of undetermined portions of Lias fish remains should carefully examine the same, and possibly other parts may be found which may help to give further information as to the organization of this singular and interesting fish.

EXPLANATION OF PLATE IV.

Squaloraia polyspondyla, Agassiz.

Fig. 1. An almost entire example of a male individual.
Fig. 2. Detached rostrum of another male individual.
Fig. 3. Detached rostral spine of a male.
Fig. 4. Detached head and rostrum of a female.
Fig. 5. Head of original specimen, described by Dr. Riley and Prof. Agassiz, copied from table 42 of Agassiz's Poiss. Foss.

The above are all from the Lias of Lyme Regis, Dorset, and are drawn of the natural size.

Figs. 1—4 are preserved in the British Museum.

II.—On some Coniferous Remains from the Lithographic Stone of Solenhofen.

By W. T. Thiselton Dyer, B.A., B.Sc., F.L.S.

I. *Araucarites Häberleinii*, Dyer.

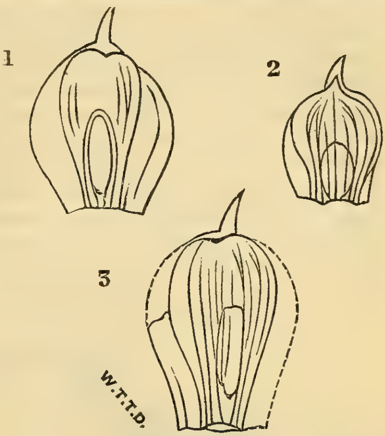
The Geological Department of the British Museum possesses the fine collection of fossils from the Solenhofen Oolites, which was formed under specially favourable circumstances by Häberlein. Its importance is at once apparent when it is remembered that it contains the specimen of *Archæopteryx macrura*, described by Owen.

The collection includes, besides the vertebrata, a large series of more or less perfectly preserved plant-remains. The greater part of these may be referred with some degree of certainty to the Coniferæ, although, with the rarest possible exceptions, they consist merely of foliage.

I have, however, I think, without doubt, determined amongst

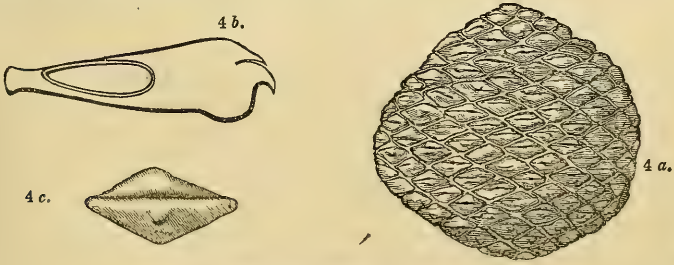
[1] In the Upper Oolite, or Lithographic Stone of Solenhofen, and elsewhere, remains of many species of Rays are found, some of large size, in which the fin-rays and the dermal covering are perfectly conserved. There is in the British Museum an example of a small species (*Squatina speciosa*, v. Mey.) from the above locality, in which these parts are beautifully preserved. They are also found in a nearly equal state of preservation in a fissile limestone of Cretaceous age in the Lebanon; and of which there are some good examples in the collection.

them scales of an Araucarian cone. For this determination I cannot claim much credit; the scales are so similar in structure to those from the Stonesfield Slate, of which Mr. Carruthers pointed out the true nature three years ago,[1] that a glance was sufficient to ascertain what they were. In the accompanying woodcut (Figs. 1–3) the scales from Solenhofen are drawn of the same size as the original specimens. A few words of explanation as to the general structure of the scales in *Araucaria* will make the Figures more intelligible.



Araucarites Häberleinii, Dyer.

If we examine a cone of some species of *Pinus*, especially in its young state, we shall succeed in making out two distinct sets of scales. The scale, in fact, which ultimately has the seeds attached to it is subtended, as it were, below by another scale which bears no seeds. This is generally termed the bract-scale, and is in some instances more or less leaf-like. These bract-scales are, homologically, the leaves belonging to the axis of the cone. But, since it is without parallel in the vegetable kingdom that the same axis should bear two sets of leaves, one set in the axils of the others, it follows that the seed-bearing scales do not belong to the primary axis of the cone at all. They must belong, therefore, to secondary axes springing from the axils of the bracts. We may account for the apparent absence of these secondary axes in one or other of two ways. They may give off the seed-bearing scale as a leaf, and be in all other respects wholly abortive; or they may exist, confluent with a pair of leaves, in the seed-bearing scale itself. There are facts which lend themselves to the support of this last view as most probable.



Araucarites sphærocarpus, Carruthers.[2]

[1] Geol. Mag., 1869, p. 3.

[2] (*a*) is a reduced representation of the whole cone; (*c*) is an end view of one of the scales showing the two apices, of the natural size; (*b*) is a longitudinal section of a scale. For (*a*) and (*c*) I am indebted to Mr. Carruthers; (*b*) is from the Geol. Mag., 1871, p. 543.

In *Araucaria* there is at first sight the peculiarity that the scales borne by the *primary* axis of the cone are themselves those which carry the single seeds (see Figs. 4*b*. and 5). This is an important difference; if the scales of the primary axis bear the seeds, then those botanists who refuse to admit the existence of a carpellary covering distinct from the seed-bearing scale, would be obliged to regard the whole cone as equivalent to a single flower. If, however, the seeds are borne in the leaves of secondary axes, the cone must, on any view, be looked upon as an inflorescence. Professor Dickson has, I think, shown[1] that the structure of the Araucarian cone corresponds with that of *Pinus*, the difference being that in *Araucaria* the two scales are confluent. The combined scale has a more or less well-marked double apex which is shown very evidently on Figs. 4*b*. and 5; the meaning of this on any other than Professor Dickson's view is inexplicable.

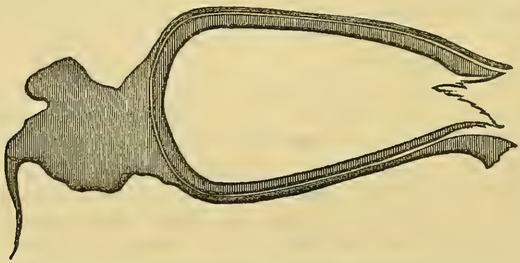


Fig. 5. Longitudinal Section of Scale of *Araucaria Bidwilli.*[2]

The genus *Araucaria* has been divided into two sections; in *Columbea* the scales are destitute of the winged margin, which is characteristic of *Eutacta.* The two species of *Araucarites* which Mr. Carruthers has founded upon scales from the Lower Oolite both belong to the latter section. To this must also be referred the Upper Oolite species from Solenhofen. At first sight it might be supposed that the inner outline shown in Figs. 1–3, belonged to the upper or seed-bearing scale. This, however, cannot certainly be concluded, as it only marks the commencement of the wing. Fig. 2 shows the apiculus or minute free portion of the upper scale (*lepidium* of descriptions).

The Solenhofen scales exhibit very evidently the remains of the fibro-vascular bundles; they can only be demonstrated in recent scales by maceration. It would therefore seem that the scales must have undergone a considerable amount of decay before final inclosure in the material of their present matrix. Zuccarini[3] has studied the arrangement of these bundles. According to his observations, in the seed-bearing scales of *Pinus* "the rays proceeding from the principal vascular fasciculus converge again towards the apex," and present a distinctly dichotomous arrangement (p. 36). The dichotomy, however, takes place in *Pinus* close to the bottom of the scale,

[1] Edin. New Phil. Journ., 1861, pp. 198, 199.

[2] Geol. Mag., 1866, p. 251.

[3] Ray Soc. Rep. and Pap., 1845.

so that it is traversed by simple curved veins converging at the apex. But in *Sciadopitys* it appears from one of Zuccarini's figures (t. 3, f. 7) that the dichotomy is not confined to such narrow limits as in *Pinus*, and that consequently forked veins occur higher up in the scale. This was to some extent apparently also the case in the Solenhofen scales.

Mr. Carruthers has named his species after the persons from whose collections he has described them. I shall follow his example in attaching the name of Häberlein to the species from Solenhofen.

Araucarites (*Eutacta*) *Häberleinii*, Dyer, n. sp.—Strobili squamis late obovatis vel subrhomboidalibus abrupté acuminatis, lepidio brevissimo, nervis leniter curvis demum furcatis.

III.—On the Climate of the Post-Glacial Period.

By S. V. Wood, Jun., F.G.S.

It has been generally assumed by geologists that the climate of the period which followed the elevation of the Glacial beds was one of gradual amelioration from a rigorous to a mild one. The Rev. O. Fisher some time since, however, in describing certain appearances presented by some superficial sections which he denominated "Trail,"[1] suggested that they were due to a second period of cold, which he regarded as having occurred between 100,000 and 200,000 years back. Without adopting, in all respects, the views of Mr. Fisher, I yet think that the facts, as far as yet known, point to the conditions of climate during the Post-glacial period having been the reverse of what has been generally assumed with respect to them; and I propose here to give some reasons for that idea.

1. *The Geological evidence.*—Speaking for the Eastern side of England, as that which has more particularly come under my notice, there seems to be an absence of any evidences of ice-action during the emergence of the land from the Glacial sea. If masses of shore-ice, such as now gather in winter round the coasts of Labrador and Hudson's Bay, and even in the Gulf of St. Lawrence, had, during this submergence, accumulated in the numerous inlets and channels formed by the partially emerged rocky districts of the North of England, and of Scotland, such ice travelling southward in summer would, we might expect, have passed over the lower and therefore not yet emerged country of East Anglia, and have plentifully bestrewn it with some of those blocks that in millions cover the surface of the Glacial drift of these rocky districts; but I have never met with a boulder in East Anglia whose presence may not be traced to weathering from the Glacial clay beneath it, or to the denudation from the place of its occurrence of Glacial clay in which it was once embedded.

This negative evidence is not, however, altogether satisfactory, because, by a parity of reasoning, we should expect the surface of East Anglia to have been strewn with similar blocks by ice that

[1] Quart. Journ. Geol. Soc., vol. xxii., p. 553; Geol. Mag., Vol. IV., p. 198.

drifted from the same mountainous districts during the late part of the Glacial period itself, when, the continental ice to which the Glacial clays are due having passed away, these districts had become an archipelago in which the boulder-sands, boulder-beds, and boulder-earth, which constitute the Glacial drift of these mountain districts, were, according to my view, accumulated; but we do not find evidences of such a distribution of surface-blocks in East Anglia. It is, however, quite conceivable that these last results of the ice-action of the Glacial period were altogether removed by the considerable denudation to which the sea-bottom must have been exposed during its emergence. As a rule, all large areas from which the Glacial beds have been removed by Post-glacial denudation are thus destitute of boulders. Such, for instance, is the case with the Great Valley of the Thames, the eastern part of which, having its northern heights crowned by Glacial clay, is proved to have been once covered by the Glacial sea;[1] but in which, as also in the wide sheet of Post-glacial gravel that occupies the lower part of the valley, no boulders, save those in the Grays brickearth alluded to in the sequel, occur. It can hardly be denied that into such valley, so far as it had then come into existence, some of the winter-formed ice issuing in summer from the half-emerged valleys and glens of the mountain districts, and drifting southwards, would be carried by the tide, and distribute blocks, if at that time the climate of these districts was such as to generate marine ice.

It is very important, in this question, that the distinction between Glacial-clay and Boulder-clay should be kept in view. Glacial-clay may be Boulder-clay, or be nearly destitute of boulders, according to the nature of the country over which the Glacial-ice travelled before shedding at its seaward termination the *moraine profonde,* to be distributed over the contiguous sea-bottom as Glacial-clay. If that country be a rocky one like the North of England, or like Scotland, boulders abound in the clay; but if an extensive area of soft strata intervene between the sources of the ice-stream and its seaward termination, such as was the case in East Anglia, the bulk of the resulting Glacial-clay consists of the degraded material of these softer strata, and the boulders in it form but a subordinate feature. Where this kind of clay lies against the Chalk Wold of Lincolnshire, it is nothing but reconstructed chalk, so pure as to be burnt for lime; and generally all over the counties south of the Humber and east of the Trent, the Glacial-clay is principally formed of rolled chalk, with boulders only sparsely scattered through it. On the other hand, Boulder-clay produced by the dropping of boulders over a sea-bottom from coast-ice, without the presence of any sea-terminated glacier, with its submarine terminal moraine, is a different thing, presenting none of that glacially degraded material which constitutes the mass of Glacial-clay. In the East of England we

[1] Until the objections submitted by me at p. 92 of Vol. VIII. of this MAGAZINE to any other than a submarine origin for this clay are removed, I assume the existence of such clay on the heights above the Thames Valley as proof of the Glacial sea having covered them.

find such a non-Glacial clay in that of Hessle, in Yorkshire, and also, as it appears to me, in the South of England along the coast of Sussex, about Selsey and Bracklesham.[1] Both the Hessle and the Sussex clays occur in the neighbourhood of the chalk country, and ought, if accumulated under similar Glacial conditions to the Glacial-clays of East Anglia, to be similarly constituted, so far as its general character is concerned, which is not the case. I shall refer in the sequel to both these clays, which seem to me to have been accumulated long after the emergence of the principal part of the land from the Glacial sea, and long after the Glacial period proper had passed away; and to furnish evidence of a return to cold conditions after a period of warmth, during which Northern Europe became stocked by the great Mammalia.

2. *The Palæontological evidence.*—It is well known that Northern Europe and Asia were inhabited, after the emergence from the Glacial sea, by various species of large mammalia, and notably by several species of the genera *Elephas, Rhinoceros,* and *Hippopotamus,* whose living congeners inhabit exclusively hot countries. The occurrence, in a frozen state, in Siberia, of individuals belonging to two out of these genera, clad in a coat of hair, seems to have led geologists to the conclusion that these pachydermata, as well as the Cave Lion, were specially adapted for a cold climate; and that their extinction before the historical period, all over Europe, and Central and Northern Asia, must have been due to some other cause than that of inclemency of climate; and the favourite hypothesis seems to have been that they owed their extinction to the attacks of Post-glacial man, whose implements are not unfrequently associated with their remains in Post-glacial deposits. A little reflection will, however, I think, show that much improbability attaches to this idea.

Africa has been from the remotest historical times peopled by numerous inhabitants, and to these the use of iron seems long to have been known; but until the ivory hunters with fire-arms, and more recently with rifles and explosive bullets, began to persecute them, the African pachydermata seem to have maintained their numbers. Similarly the civilization of Southern Asia is very ancient, and the use of metals probably dates back there several thousand years; but what have the civilized Asiatics with the accessories of metal weapons and of the domesticated horse done towards exterminating the Asiatic pachydermata and great felines? Modern sportsmen with their destructive weapons have done more towards this in half a century than has been done during thousands of years of antecedent civilization. Are we then to suppose that thousands of years before this civilization even commenced (and when no doubt similar uncivilized races existed in Southern Asia and in Africa to exterminate, if they could, the great mammalia of those regions also) the scattered tribes of men who managed to exist along the shores and rivers of Europe, and of Northern and Central Asia, exterminated with their

[1] Brought to notice by Mr. Godwin-Austen. See Quart. Journ. Geol. Soc., vol. xiii., p. 55. Like the Hessle, the Sussex Clay contains numerous chalk fragments, but is quite different from chalky *Glacial* clay.

feeble weapons of bone and flint the gigantic pachydermata and felines of the Post-glacial period? Fancy attacking a rhinoceros, whose hide will turn a rifle bullet, with a flint hatchet or a bone skewer! Contrivances of various kinds have probably been employed by the Asiatics and by Africans, from time immemorial, for ensnaring these animals; but no appreciable effect in diminishing their numbers seems to have resulted. Von Wrangel describes the soil of Siberia as having teemed with the bones and tusks of the elephant, before it had been so much ransacked by the ivory hunters; and he mentions that in some islands of the Arctic Sea, which lie off the Siberian coast, forest beds occur full of elephantine remains which are now beyond the limit of arboreal vegetation, and where now a moss-covered soil only exists, forming a favourite haunt of the reindeer. No one who reads his account of the few wandering tribes that now inhabit the Siberian wastes, and which seem to be in a condition scarcely superior to that of the Post-glacial bone and flint implement races, can suppose that they exterminated the great herds of elephants that once roamed over Northern Asia, for they cause no diminution in the numbers of the easily-vanquished herds of reindeer, which they attack and slaughter while crossing the rivers, since these return again in equal numbers another year.

Mr. Dawkins has pointed out that the remains of the reindeer occur in certain Post-glacial deposits only, and more particularly in those of the caves, and that with them are associated the remains of the more recent species of extinct pachydermata; and reasoning from the habits of their living analogues, we may without qualification assert that conditions which would be essential for the subsistence of the pachydermata would be unfavourable for the reindeer, and *vice versa.* The reindeer subsists principally on a moss, which grows rapidly over the frozen soil of the regions skirting the Arctic Sea, upon which arboreal vegetation will not exist, retiring from these mossy wastes to the woody regions for a season only; and no large herbivorous animal, except the musk ox, is able to sustain life in the regions that are peculiarly the haunts of the reindeer. The rhinoceros and elephant, on the other hand, require an arboreal vegetation for their support, and are never away from it; and however the hippopotamus may have struggled against them during its decline, we can scarcely suppose that it could ever have been tempted to *migrate into* a region of frozen rivers, or to abandon the abundant feeding ground afforded by the banks and swamps of warm southern rivers for the frozen and barren wildernesses frequented by the reindeer.

The question then arises, how do we come to find the remains of such incongruous animals in association in Post-glacial deposits? The answer appears to me to be, that when the pachydermata spread themselves over Northern Europe, after the Glacial period, the climate was mild and equable; and that it was owing to a subsequent and late Post-glacial refrigeration that the reindeer coming from the North overran the country thus already occupied by the great mammalia; and that these latter, as the cold gradually progressed, adapted themselves as best they could to its adverse influence, until this eventually brought about their extinction; the assumption of a hairy coat being merely one of those efforts to protect itself which nature helps animals to make. Doubtless the pachyderms for a long time resisted these influences by a southward migration during winter, when their places were taken by the reindeer, which, in its turn retiring northward in the summer, gave place during that season to the pachyderms; and in this way, probably, their bones have become intermingled in Post-glacial deposits. But this southerly migration of the pachyderms being limited in Europe by the Mediterranean and Black Seas, and in Asia by the great mountain chains that stretch across the centre of that continent, would only afford relief so long as the cold did not necessitate their more southerly retreat. The same kind of problem seems presented to us by North America, where the Tapir,[1] found fossil in Carolina, but now confined to the south of the Panama Isthmus, once ranged; and where the larger felinæ, which abound in the southern part of North America, decline to follow their prey into the inclement region of the north.

Mr. Dawkins has dwelt upon the absence of reindeer remains from those older Post-glacial formations, such as the Brick-earths of the eastern valley of the Thames, and of Clacton, which yield a mammalian fauna with a somewhat older facies than the generality of the Post-glacial deposits,[2] and with which fauna the river shell *Cyrena fluminalis* occurs in association. He has indeed insisted that the mammalia of these formations indicate an even warmer climate than now prevails in Britain;[3] and so much was he impressed with this, and with the older facies presented by the remains, that he at first assigned a Pre-glacial age to the formations in question. This view of their age he has since relinquished,[4] but, with the exception of the occurrence of some remains of the Musk-ox, the inference he drew as to the warmer climate and older palæontological aspect presented by the group of mammalia yielded by these formations remains, so far as I know, untouched. These formations, I have endeavoured elsewhere to show,[5] seem to me to have been accumulated about that middle stage of the Post-glacial period when conditions of climate adequate to produce ice, capable of the transport of blocks, were again coming upon a region that had long enjoyed a temperate climate. If we look at the distribution of the existing species of Elephant, Rhinoceros, and Hippopotamus, we see that their northerly migration into the regions once occupied by their fossil congeners is prevented by the Mediterranean and Black Seas, and by the lofty and snow-capped mountain-ranges which stretch from the Black Sea to the southern frontier of China; the bridge which Capt.

[1] I omit the Mastodon, as we have no living analogue of that animal wherewith to judge of its climatal peculiarities.

[2] Quart. Journ. Geol. Soc., vol. xxiii., p. 108; vol. xxiv., p. 515; vol. xxv., p. 213. The presence of the Megarhine Rhinoceros seems to be the special older feature in the fauna of the Eastern Thames Brickearths.

[3] Ibid. [4] Ibid. vol. xxv., p. 217.

[5] Ibid. vol. xxiii., p. 394. Geol. Mag., Vol. III., pp. 57, 99, 348, and 398.

Spratt has shown to have once probably existed about Malta,[1] and by which intercourse between the two continents was formerly possible, having probably disappeared at the period before alluded to, when the southerly winter migration of the pachydermata was arrested. Now the molluscan associate of the great mammalia in the older Post-glacial deposits of Britain, *Cyrena fluminalis,* seems to be cut off from Europe and from Northern Asia by nearly the same barriers as those which confine the great pachydermata, since it ranges at the present day from the Nile, through Syria, to the Himalayas and China; while, so far as is yet known, this shell has not occurred in this country in association with Reindeer remains.

It should not be forgotten, in this question, that the remains of some *Coleopterous* insects, obtained by Mr. Fisher from an undoubted Post-glacial deposit at Lexden (and from which as yet we have no occurrence of Reindeer remains), were examined by Mr. T. V. Wollaston, F.L.S., who, guarding himself from a decided opinion as to the specific identification of the specimens, states that from two of them (especially a *Cossiphus,* which he says does not occur north of the Pyrenees) he did not think there could be much doubt that a warmer temperature than at present obtains was indicated by the forms thus procured by Mr. Fisher.[2] If Mr. Wollaston's view be correct, it would be only necessary to suppose that this Post-glacial deposit of Lexden preceded others in which the remains of insect groups resembling those of Northern Europe occur.

3. *The Geological evidence resumed.*—At Paull Cliff and Kelsea Hill, in Yorkshire, there occurs a gravel, containing, in association with marine shells, this freshwater molluscan associate of the Megarhine Rhinoceros in the Thames Brick-earths, *Cyrena fluminalis,* which, like its Mammalian associate, inhabited this country in preglacial times. This gravel, at one of these localities, is seen to rest on the Glacial-clay, and at the other to be overlain by the non-glacial Boulder-clay of Hessle previously alluded to. The marine mollusca occurring with it, moreover, are clearly Post-glacial, being all of living species, which, with two or three exceptions found in seas immediately to the North, inhabit British seas; contrasting in this respect with the Glacial-clay on which the gravel reposes, which yields (not far off, at Bridlington) a more arctic fauna, and one containing the two well-known Crag species *Nucula Cobboldiæ* and *Tellina obliqua,* whose nearest living anologues occur in the Pacific. The presence of this fluviatile shell in swarms in this gravel shows that the land had emerged from the glacial sea so as to support a river not far distant; and the position of the gravel thus overlain by the Hessle-clay, is shown by the coast section to occupy troughs cut out of the deeply-denuded glacial beds. We cannot doubt, therefore, that we have here one of the deposits of the earlier part of the Post-glacial period, similar to the Brick-earths of the Eastern Thames valley, that are full of the same shell; and that in its overlay by the non-glacial Boulder-clay of Hessle we get evidence of the incoming,

[1] Quart. Journ. Geol. Soc., vol. xxiii., p. 292.
[2] Quart. Journ. Geol. Soc., vol. xix., p. 399.

about this time, of ice conditions adequate to the transport of small boulders, such as is evinced by the remarkable nest of boulders which occurs in the Brick-earth at Grays, in the Eastern Thames valley.

I have in various papers endeavoured to show that the South and South-east of England was, during the earlier part of the Post-glacial period, covered principally by sea, the bottom of which was undergoing disturbance and great denudation from subterranean action, the country to the North of the Thames being land, and penetrated by small rivers in which these *Cyrena*-bearing Brick-earths accumulated; and I have given restoration maps in which I have endeavoured to trace the emergence of the South of England from this stage.[1] Now it is remarkable that in all the great sheet of the Thames gravel which preceded this Brick-earth we should get no traces of boulders, while so many should occur in the Brick-earth itself; and the circumstance seems to me to indicate the absence of ice-action during the deposit of the former, and its commencement during the accumulation of the Brick-earths. Further, in those gravels of Hampshire which, in the paper last referred to, I have on totally different evidence endeavoured to correlate with these *Cyrena* Brick-earths, boulders of Sarsen sandstone occasionally occur.[2] These seem to be confined to the gravels at medium and lower levels, and to be absent from that higher part of the Hampshire sheet which I have attempted to connect with the main and higher sheet of Thames gravel.

In the same paper, and in the restoration maps accompanying it, I have endeavoured to show that the emergence of the principal part of the South of England, and the retreat of the sea within the Valley of the Weald, the denudation of that valley, and the eventual reversal of the drainage in it, was posterior to these *Cyrena* Brick-earths of the Thames Valley, and occupied that long period which I call the later part of the Post-glacial one; and I also endeavoured to show that the non-glacial Boulder-clay of the Sussex coast, in which very large blocks derived from the West occur, belonged to this later Post-glacial period. I have already pointed out that this clay, like the Hessle, had it been formed during the Glacial period, could hardly have failed to present those physical features which are common to all Glacial-clay formed in the neighbourhood of soft strata, and especially of the Chalk; and it is most important that it offers in the molluscan fauna of the deposit which it overlies similar corroborative testimony of Post-glacial age as does the Hessle clay. Like the latest part of the Crag, all the Glacial beds of the East of England yield some mollusca which are not known living, and others whose present habitat is in distant and northern areas such as the North American coast, Greenland, etc. The oldest of these, the pebbly sand of Norfolk and Suffolk (the shallow water equivalent, as I regard it, of the Cromer Till), has some of both of these classes; the East Anglian Middle Glacial has this feature even more marked,

[1] Quart. Journ. Geol. Soc., vol. xxvii., p. 20.

[2] For some examples see Geol. Mag., Vol. III., p. 296.

while the yet newer deposit of Bridlington has two of the first and several of the latter class, and the fauna of all of these three formations presents more or less affinity to that of the Crag, the molluscan remains in all being thoroughly fossilized. The bed, however, which underlies this Sussex clay presents the greatest contrast to these Glacial deposits and to the Crag, as it contains a somewhat numerous molluscan fauna, in fine preservation, which is not only hardly fossilized at all, but consists entirely of species still living, and living, moreover, in contiguous or but little distant seas, and those Southern ones. These living species nearly all occur on our present Southern coast, while of the rest a few are confined to the Lusitanian, and one or two to the Mediterranean coast;[1] affording pretty clear evidence that at a period not very far back, but anterior to those ice conditions to which the great blocks occurring in the overlying clay are due, a warmer and more Lusitanian-like sea washed the southern shores of Britain.[2] Associated with the mollusca in this bed occur Mammalian remains which present none of those older features attaching to the remains from the *Cyrena* Brick-earths of the Thames Valley, and of course still less of those attaching to the pre-glacial forest beds of Norfolk; and which, although neither the Reindeer nor Musk-ox are among them, are grouped by Mr. Dawkins[3] with the ordinary Post-glacial Mammalian fauna of Britain, as distinguished from the Thames Brick-earth group.

This non-glacial Boulder-clay appears to me to be of even later age than that of Hessle; and to present evidences of erratic transport requiring much more ice-power, some of the blocks described by Mr. Godwin-Austen and by Sir Charles Lyell being enormous. Tracing the sequence of events from quite different evidence to the above, I endeavoured to show in the before-mentioned paper that this Sussex clay was formed near the close of those Post-glacial changes to which I trace the present condition of the South and South-east of England;[4] that is to say, just about the stage when the Weald was completely deserted by the sea, and its drainage reversed into its present direction; in the gravels of which drain-

[1] A list of 38 species from this deposit is given by Mr. Godwin-Austen in Quart. Journ. Geol. Soc., vol. xiii., p. 50, and as many more have since been obtained by Mr. Alfred Bell. Mr. Godwin-Austen in the same paper also notices the Mammalian remains.

[2] In the paper in vol. xxvii. of Quart. Journ. before referred to, I endeavoured to show that subsequent to the formation of the Thames Brick-earths, and prior to the accumulation of this Sussex molluscan deposit, an isthmus joining Kent to France had come into existence, which divided the Lusitanian connected waters of the South of England from those of the North Sea. The marine shells of the Post-glacial gravels of East Anglia have a more northerly character than those of the Sussex bed, though agreeing with them in belonging all to living species, that with a few exceptions (which occur in contiguous seas) yet survive in British waters.

[3] Quart. Journ. Geol. Soc., vol. xxv., p. 195. See column headed Bracklesham.

[4] We get no evidence of this late Post-glacial ice-action over Essex, Suffolk, and Norfolk, except it be in Mr. Fisher's 'trail,' because, as it appears to me, these counties were then all land, having, in common with all England, at a still later or prehistoric period, undergone that subsidence which is indicated by the submerged forests round our coasts.

age there occur, according to Mr. Godwin-Austen, some large ice-transported blocks. This seems to me to have been the period when the Reindeer frequented Britain and the South of France, and that to which so many of our river gravels belong.

Whether any geologists may be disposed to agree in the view which I have put forward or not, the question I think demands investigation; and the more this is attempted, the more, I think, geologists will become satisfied of the greater remoteness of the true Glacial period, and of the far longer duration of the Post-glacial, than has been hitherto supposed.

IV.—On some Points in the Geology of the East Lothian Coast.

By G. W. and F. M. Balfour,

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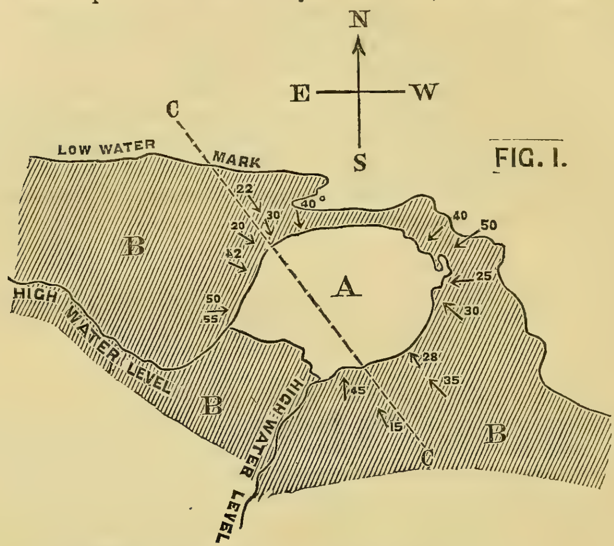
THE interesting relation between the Porphyrite of Whitberry Point, at the mouth of the Tyne near Dunbar, and the adjacent sedimentary rocks, was first noticed, we believe, by Professor Geikie, who speaks of it in the Memoirs of the Geological Survey of East Lothian, pages 40 and 41, and again in the new edition of Jukes's Geology, pp. 269. The volcanic mass which forms the point, consists of a dark felspathic base with numerous crystals of augite: it is circular in form, and is exposed for two-thirds of its circumference in a vertical precipice facing the sea, about twenty feet in height.

The rock is traversed by numerous joints running both in a horizontal and in a vertical direction. The latter are by far the most conspicuous, and give the face of the cliff, when seen from a distance, a well-marked columnar appearance, though the columns themselves are not very distinct or regular. They are quadrangular in form, and are evidently produced by the intersection at right-angles of the two series of vertical joints.

It is clear that the face of the precipice has been gradually receding in proportion as it yielded to the action of the waves; and that at a former period the volcanic rock extended considerably further than at present over the beds which are seen to dip beneath it. These latter consist of hard fine-grained calcareous sandstones belonging to the Lower Carboniferous formation. Their colour varies from red to white, and their prevailing dip is in a N.W. direction, with an average inclination of 12–20°. If the volcanic mass is a true intrusive rock, we should naturally expect the strata which surround it to dip *away* in all directions, the amount of their inclination diminishing in proportion to their distance from it. We find, however, that the case is precisely the reverse: as the beds approach the base of the cliff, they dip *towards* it from every side at perpetually increasing angles, until at the point of junction the inclination amounts in places to as much as 55 degrees. The exact amount of dip in the various positions will be seen on referring to the accompanying map.

Fig. 1.—Map of Strata at Whitberry Point. Scale, 6 in. to the mile.



A. Lava sheet.
B. Sandstone Beds, dipping from every side towards the Lava.
CC. Line of Section along which Fig. 2 is supposed to be drawn.

We conceive that the phenomenon is to be explained by supposing the orifice through which the lava rose and overflowed the surface of the sedimentary strata to have been very much smaller in area than the extent of igneous rock at present visible; and that the pressure of the erupted mass on the soft beds beneath, aided perhaps by the abstraction of matter from below, caused them to incline towards the central point at a gradually increasing angle. The Diagram, Fig. 2,

Fig. 2.—Vertical Section through CC. Diagram (Fig. 1).

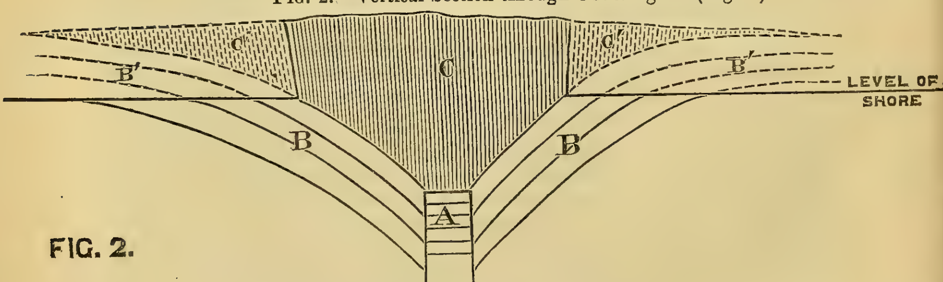


FIG. 2.

A. Orifice by which the lava ascended.
B. Sandstone Beds.
B′. Hypothetical extension of ditto.
C. Sheet of lava spread over the sandstones B.
C′. Hypothetical extension of ditto.

will serve further to illustrate this hypothesis. A. is the neck or orifice by which the melted matter is supposed to ascend. C. shows the sheet of lava after it has overspread the surface of the sandstone beds B., so as to cause them to assume their present inclination. The dotted lines represent the hypothetical extension of the igneous mass and sandstones previous to the denudation which they have suffered from the action of the waves.

Professor Geikie, in his admirable treatise on the Geology of the county,[1] adopts a view on this subject which is somewhat different from that which is suggested in this paper. He considers that the whole mass is an intrusive neck of rock with perpendicular sides; and that it once filled up an orifice through the surrounding sedimentary strata, of which it is now the only remnant.

He admits that the inclination of the sandstone beds towards the igneous mass in the centre is a phenomenon that is somewhat difficult to explain, and suggests that a subsequent contraction of the column may have tended to produce such a result. To use his own words: "In the case of a solid column of felstone or basalt, the contraction of the melted mass on cooling may have had some effect in dragging down the sides of the orifice." [2]

But, apart from other objections, it is scarcely conceivable that this result should have been produced by the contraction of the column.

In his recent edition of Jukes's Manual of Geology (p. 269), in which he also refers to this instance, he states that in other cases of "necks" it is found to be an almost invariable rule, "that strata are bent down so as to dip into the neck all round its margin." We are not aware to what other instances Prof. Geikie may allude; but on referring to his Memoir on the Geology of East Lothian, we find that he states in the cases of 'North Berwick Law,' and 'Traprain' (which he compares with the igneous mass at Whitberry Point), that the beds at the base of these two necks, where exposed, dip *away* from them, and that at a high angle.

In support of the hypothesis which we have put forward, the following arguments may be urged:

(1.) That in one place at least the sedimentary strata are seen to be actually dipping beneath the superincumbent basalt; and that the impression produced by the general relation of the two rocks is, that they do so everywhere.

(2.) Since the columns into which the lava is split are vertical, the cooling surface must have been horizontal: the mass must, therefore, have formed a sheet, and not a dyke; for, in the latter case, the cooling surfaces would have been vertical.

(3.) It is difficult to conceive, on the supposition that the volcanic rock is a neck with perpendicular sides, that the marine denudation should have uniformly proceeded only so far as to lay bare the junction between the two formations. We should have expected that in many places the igneous rock itself would have been cut down to the general level, whereas the only signs of such an effect are shown in a few narrow inlets where the rock was manifestly softer than in the surrounding parts.

[1] Memoirs of Geological Survey of Scotland, Sheet 33, pp. 40, 41.

[2] Note on p. 41 of Mem. Geol. Survey of East Lothian.

The last objection is greatly confirmed by the overhanging cliffs and numerous blocks of porphyrite which lie scattered on the beach, as if to attest the former extension of that ancient sheet of which these blocks now form but a small remnant. Indeed, the existence of such remains appears sufficient of itself to condemn any hypothesis which presumes the present face of the cliff to have formed the original boundary of the mass.

It may be fairly objected to our theory, as Prof. Geikie himself has suggested, that the high angle at which the strata dip is difficult to account for. But, in fact, this steep inclination constitutes the very difficulty which any hypothesis on the subject must be framed to explain; and it is a difficulty which is not more easily solved by Prof. Geikie's theory than by our own.

V.—On Changes of Climate during the Glacial Epoch.

By James Geikie, F.R.S.E.,
District Surveyor of the Geological Survey of Scotland.

Fifth Paper.

(*Continued from the March Number, p.* 111.)

THE older valley-gravels and cave-deposits of England contain, as every geologist knows, a remarkable intermingling of northern and southern forms of animal life. To account for this anomaly various theories have been advanced. There are few who do not admit, to begin with, that species such as the hippopotamus and the musk-sheep could not have lived side by side throughout the year in the same country. The conditions necessary for the support of the one would be fatal to the other. Some writers, therefore, have inferred that the occurrence of the remains of both these creatures in our superficial deposits points to former fluctuations of climate during the accumulation of these beds; while others hold that it only indicates a period of strongly contrasted summers and winters. There are yet other theories which have been put forward to explain the difficulty. Mr. Prestwich, for example, has suggested that the hippopotamus was possibly protected by a coat of fur, and may thus have been able to exist under the same climatal conditions as the musk-sheep, the mammoth, and the Siberian rhinoceros. But the hippopotamus is not the only animal that would seem to indicate that, at some period during the formation of the valley-gravels and cave-deposits, the climate of Britain was comparatively warm,—*Elephas antiquus* and the two rhinoceroses (*R. megarhinus* and *R. leptorhinus*) appear to tell the same story. It is hardly possible to believe that all these species were fitted like the mammoth to brave the exigencies of a severe climate. The more reasonable view is that adopted by most palæontologists, namely, that the hippopotamus, the elephant, and the two rhinoceroses are true southern forms, and could only have existed in Britain under mild or comparatively warm conditions. At all events, as regards the hippopotamus this conclusion appears inevitable, for, as Sir John Lubbock remarks, "Even if protected by fur, as Mr. Prestwich supposes, the animal could never live in a country where the rivers were frozen over." I shall therefore not attempt to discuss this hypothesis further, but will confine what remarks I have to make to the two theories referred to above. The latter of these—that, namely, which supposes a period of strongly contrasted summers and winters to have prevailed during the deposition of the English valley-gravels and cave-accumulations —has lately been ably advocated by Mr. Dawkins, who has brought to the task a wide knowledge of the subject. His case is stated with great clearness, and he seems to have employed all the arguments that can be adduced in its favour. Yet I cannot see my way to accept his conclusions. Had these conclusions followed from a consideration of palæontological evidence alone, I should hardly have ventured to dispute the position maintained by one who has devoted so much time to this special study; the question, however, is one chiefly of climate and physical conditions.

By noting all the localities where our superficial deposits have yielded remains of the Quaternary mammalia, he has shown[1] that these fossils are confined to the low-lying districts of England; and he accounts for their absence from the Post-glacial beds of Wales, the north of England, and Scotland by supposing that these regions were covered with ice at the time that the mammalia were in full occupation of Central and Eastern England. At this period Britain was connected across the bed of the German Ocean and the English Channel with the Continent, and he explains the intermingling in the same deposits of hippopotamus and other southern forms with those of an Arctic fauna, by supposing that in "summer-time the animals now only found in the warmer regions migrated northwards, and in winter-time those now found in the Arctic regions went southwards." Sir Charles Lyell had previously suggested that the hippopotamus might have been a summer visitant only; and this, Mr. Dawkins says, is the only "hypothesis that satisfies all the conditions of the problem."

But does it really do so? What kind of climate, let us ask, would be likely to result were Scotland and the mountainous districts of England and Ireland to be covered with snow and ice? Mr. Dawkins thinks that it would be "somewhat similar to that of the vast plains of Siberia extending from the Altai Mountains to the Arctic Sea, or to that offered by the inland climate of North America. In Siberia," he continues, "we meet with every gradation in climate, from the temperate down to that in which the cold is too severe to allow of the growth of trees, which gradually decrease in size as the traveller passes northwards, and are replaced by the grey mosses and lichens of the low marshy tundras. Throughout the north the winter cold is intense, and in the southern portion is almost com-

[1] Quart. Journ. Geol. Soc., vol. xxv., p. 192. Mr. Dawkins has further explained and illustrated his views in a paper, "On Pleistocene Climate and the Relation of the Pleistocene Mammalia to the Glacial Period."—Popular Science Review for October, 1871.

pensated for by the great summer heat and its marvellous effect on vegetation. . . . In both America and Siberia there is a zone of debatable ground, in which the mammals of the Arctic and temperate provinces are continually oscillating to and fro, according to the seasons. And in this their skeletons could not fail to be mixed together in the deposits of the rivers." But before we decide that the climate of England in "Pleistocene" times resembled that of Siberia and North America at the present day, it is necessary to ascertain whether the causes that induce the latter could possibly have existed in Britain at a time when, as it is supposed, glaciers still covered large areas in that country and Ireland.

At Jakutsk (62° N. lat.) the temperature of January is—43° 8′ F., while that of July is 62° 2′—truly a wonderful contrast! The causes of the intense winter are not far to seek. During that season every wind that blows across Siberia, no matter whence it comes, is bitingly cold. The west winds that temper our winters with the warmth of the Gulf-stream are robbed of their moisture and cooled down before they cross the snows of the Ural Mountains to pour into Siberia. The gales from the Arctic Ocean are still colder, nor is much warmth derived from the winds that sweep northwards from the high Mongolian plateau. In summer-time the conditions are reversed. Dry and scorching winds reach Siberia from the west, and the heat of the Mongolian deserts is wafted from the south; while at the same time the northern plains are warmed by the continuous shining of the Arctic sun; and thus the temperature rises rapidly all over Siberia. In North America the seasons are also more marked than with us, and the causes for this are somewhat similar to those which induce the more strongly contrasted summers and winters of Northern Asia.

If we could obliterate the German Ocean and the English Channel, would this change bring about summers and winters as well marked as those that characterize the higher latitudes of Asia and America? Surely not, for so long as our western shores continued to be washed by the Atlantic, our climate would necessarily partake of an "insular" character. The summers would possibly be a little warmer, and the winters a little colder, but there is nothing to justify the supposition that the seasons would at all resemble those of Siberia or the inland parts of North America. But the migrations of the Arctic and southern fauna are thought to have taken place at a time when snow-fields and glaciers were nourished in the upland districts of Great Britain. The mere presence of perennial snow and ice, however, could not possibly bestow a Siberian climate on England. With Scotland and the hilly districts of England and Ireland buried underneath snow and ice, we may reasonably infer that the glaciers of Switzerland must have greatly exceeded their present dimensions; that the mountains of the Vosges and the Black Forest would have their permanent snow-fields; and that Scandinavia would be in a truly glacial condition. In short, the winters of Europe would then necessarily be very much colder than they are now: and it follows from this that the summer temperature would also be greatly lower than at present. For if we conceive that the prevalent winds in

"Pleistocene" times came, as they do now, from the south-west, we cannot but admit that they must have been colder. The occurrence of glaciers in Britain pre-supposes a greater extension of the Arctic ice-fields, more plentiful crops of icebergs, and consequently a colder sea. Indeed, it seems more than likely, that with permanent snow-fields in Great Britain, icebergs would sail southwards in large numbers from Scandinavia, and from not a few of the fiords of the west of Scotland. The winds that set towards the western coasts of Europe would thus have to traverse a sea more or less filled with floating ice, and would be compelled to part with their warmth before they reached our shores. But, more than this, Mr. Croll has shown that, under a glacial condition of things in the Northern Hemisphere, it is highly probable that a large proportion of the heat which our island now derives from the Gulf-stream would be transferred to the Southern hemisphere; and the result of this would be to give to England a very much cooler summer than she at present enjoys. It matters little, however, from what point of the compass we suppose the prevalent winds to have come; so far as that goes, they may have issued from the north, south, east, or west: but under the physical conditions assumed to have characterized "Pleistocene" Britain, they never could have conferred a Siberian summer upon these latitudes.

It would not be difficult to show that, with the presence of perennial snow and ice in the high grounds of Great Britain, our rivers would remain frozen over for a great part of the year. During the summer they would burst their icy bonds, and, swollen with heavy rains and the torrents derived from the melting of the snow-fields and glaciers, would overflow the low grounds, and carry devastation far and wide. Over broad areas in our valleys, therefore, there could be little vegetation. Such areas as were not covered with snow might perhaps support scraggy birch and pine; and here and there tall grasses and dwarf willows might nestle in sheltered hollows; but mosses and lichens would most probably form the prevailing growths. If the "Pleistocene" hippopotamus could live on such fare, he must have been a more easily satisfied animal than his modern representative. It is true that in Arctic regions the short summer brings into bloom a number of pretty flowerets, and causes the grasses to shoot up with surprising rapidity. But this is due to the influence of a sun that keeps above the horizon during the greater part of summer. A glacial period in England, however, would not be tempered by the presence of a midnight sun in summer-time. For these and other reasons it may be safely concluded that the hippopotamus could not have lived in this country when glaciers filled our mountain valleys.

But putting aside climatal conditions altogether, and admitting for the moment that the warmth of Post-glacial Britain in summer-time was fitted to woo the hippopotamus northwards, there would still be a fatal objection to the hypothesis under review. The hippopotamus is not, properly speaking, a migratory animal. This objection, which has been frequently urged, appears unanswerable. Unless the Pleistocene hippopotamus differed very much from its living representative (and so far as we know it did not), there is no likelihood of such a bulky brute having performed the wonderful migrations which this hypothesis assigns to it.[1]

I have referred to the hippopotamus alone, but at least three of the other southern forms met with in English "Pleistocene" deposits seem to come under the same category. *Elephas antiquus* and the two rhinoceroses (*R. leptorhinus*, Owen, and *R. megarhinus*) would certainly have fared as badly as the hippopotamus if they had ventured into Britain at a time when our high grounds were covered with snow and ice. Nor, judging from what we know of their present representatives, can we suppose that these animals were migratory. Again, I think it hardly possible that the cave-lion, the hyæna, and the sabre-toothed machairodus could have visited this country under the conditions assumed. It is quite true that the lion infested Greece within historical times, and that, as Mr. Dawkins remarks, "the temperature of the mountains of Thrace was undoubtedly infinitely more severe than that of any region in which it now lives." But the temperature of "Pleistocene" Britain, according to this theory, must have been "infinitely more severe" than that of the mountains of Thrace; and the question we have to consider is whether the lion could live under conditions still more trying than those that mark the bleak "barrens" of British America or the treeless tundras of Northern Asia. I say "still more trying," because the summers of such a Britain as is thought to have existed in Post-glacial times must have been far cooler than those of Northern Asia and America are at present. With the poor and meagre vegetation which a country of this kind would be able to support, the herbivora could not have been abundant. Indeed, only a very few of the mammalia enumerated by Mr. Dawkins could possibly have existed under the conditions supposed, and probably none of these would belong to his second group, which consists of such species as still inhabit the temperate zones of Europe and America. If, therefore, we eliminate the whole of this second group, we have left only the true Arctic mammalia—the glutton, the reindeer, the musk-sheep, the pouched marmot, the tail-less hare, and the Lemming—to form provaunt for the lion and his congeners, the *Machairodus* and the hyæna. But how can we suppose it possible that these carnivora would leave the temperate zone (which,

[1] Sir Charles Lyell says (1863) geologists may freely speculate on the time when the hippopotamus "may have swum in a few summer days from rivers in the south of Spain or France to the Somme, Thames, or Severn, making timely retreat to the south before the snow and ice set in." But, according to this theory, the natations and peregrinations of our old river-horse must have extended even further north than the Thames, as certain valley gravels at Leeds bear witness. In the discussion above I have not referred to the evidence of a mild condition of things afforded by the presence of *Cyrena fluminalis* and *Unio littoralis*. If the evidence of these shells is to be trusted, however, it would furnish an additional reason why we should reject the "migration" theory, and maintain, as the more probable hypothesis, the alternative explanation suggested by Lyell, "that when the temperature of the river water was congenial to the Cyrena above mentioned, it was also suited to the hippopotamus." (Principles, 10th edit., vol. i., p. 194.)

when Arctic conditions supervened in Britain, must have shifted to more southern regions of Europe, where no doubt it was characterized by the presence of an abundant mammalian fauna), to prey upon the few reindeer and smaller animals that were likely to be found so far north as the frozen barrens of England ? Yet we know that the hyæna at least was a regular denizen of our caves, and found matters so comfortable that, according to Mr. Dawkins, its large size, as compared with that of the living animal, was probably due to "the abundance of food which it obtained."

These and other considerations, into which I cannot enter here, have led me to conclude that this hypothesis of seasonal migrations is untenable. With glacial conditions in Scotland and the hilly grounds of England and Ireland, neither temperate flora nor fauna could have existed in our country. There could be nothing in such an Arctic England, therefore, to tempt the herbivora away from the rich feeding-grounds of the then temperate zone, and just as little to wile the carnivora so far from their wonted haunts. And to suppose the hippopotamus, the elephant, and the rhinoceros capable of migrating for enormous distances, and to such a country too, is to suppose that these animals differed entirely from their present representatives.

The only other hypothesis which appears possible as an explanation of the occurrence of Arctic and Southern forms in our superficial deposits is that which assumes certain fluctuations of climate to have taken place during the accumulation of the mammal-bearing drifts.[1] But here a great difficulty meets us on the very threshold. If the presence of the hippopotamus, the elephant, and the rhinoceros, compels us to assume that at the time these animals lived in England the winters must have been mild and genial, we are at a loss to conceive how such great changes of climate could have occurred within Post-glacial times. There are few points we can be more sure of than this, that since the close of the Glacial epoch,—since the deposition of the clays with Arctic shells and the "Saxicava Sands,"—there have been no great oscillations, but only a gradual amelioration of climate. It is quite impossible to believe that any warm period could have intervened between the last Arctic and present temperate conditions, without leaving some notable evidence in the superficial deposits of Scotland, Scandinavia, and North America—these being the countries in which the passage from the later glacial beds to recent accumulations can be most distinctly traced. This fact would, indeed, afford an insurmountable objection to the hypothesis I am now about to consider, if it were necessary to suppose that the great oscillations of climate referred to supervened during Post-glacial times. For this supposition, however, there appears to be not only no sufficient reason, but the evidence, as well positive as negative, seems all against it.

[1] As I am writing for geologists, it is hardly necessary that I should remind them that this is the view Sir Charles Lyell inclines to hold (Principles, vol. i., p. 192). Sir John Lubbock, in his well-known work, is of the same opinion (Prehist. Times, p. 301).

When we come to ask why our cave-deposits have so frequently been relegated to Post-glacial times, we get no satisfactory answer. If we put out of consideration the upper layers in certain cave-deposits, there is really nothing in the bone-earths and breccias to limit the age of these accumulations to such a recent period. Accordingly, many geologists have been of opinion that the mammalian remains occurring in the caverns were introduced at various epochs, and may belong to Pre-glacial equally with Post-glacial times. Buckland thought that the great mammals existed in Britain before the period of the Diluvium or Drift, and his belief is shared by Mr. Godwin-Austen and some of our leading geologists. Professor Ramsay is decidedly of opinion that "caves such as those in which mammalian remains occur must have existed in Pre-glacial times, and therefore it would be strange," he adds, "if none of those explored contained Pre-glacial remains." But between Pre-glacial and Post-glacial times there intervened several mild inter-glacial periods, during which, as I have shown, the climate in Scotland was suited to the wants of the mammoth, the reindeer, the Irish deer, the urus, and the horse;[1] and I have also pointed out that, so far as geological evidence is concerned, there is nothing to show that some inter-glacial periods may not have been warm enough to cause all the snow and ice to vanish from Britain. If such was the case as regards Scotland, England must have been characterized by similar climatal conditions. It is therefore not necessary to suppose that any large portion of the bone-deposits was Pre-glacial; for during inter-glacial periods the caves would form dens for wild beasts, just as they must have done in pre-glacial times. To some such mild and genial inter-glacial period or periods I would refer the hippopotamus and the other southern forms met with in English caves. The conditions under which these animals lived need not have been comparable to those that characterize the tropics. All that we are entitled to infer is that the winter temperature of Britain during certain inter-glacial periods must have been mild and genial. It is by no means necessary to suppose, however, that the summers were much warmer than they are now. An equable and genial climate, with no great difference between the seasons, would nourish an abundant vegetation, and render the country habitable for a prolific mammalian fauna.

But it will be objected to this view that the species just referred to occur also in the river-gravels of England. After carefully considering the evidence, however, there seems to me not only no proof that all these older river-gravels are of Post-glacial age, but, on the contrary, many considerations induce to the belief that such is almost a physical impossibility.

[1] Remains of the Irish deer and the horse were obtained in the inter-glacial beds at Crofthead, which yielded the skull of urus. Besides these fossils there were other fragments of bone, which my friend, Professor Young, has under examination.

(*To be continued in our next number.*)

VI.—Reply to Mr. James Geikie's Correlation of the Scotch and English Glacial Beds.

By S. V. Wood, jun., F.G.S.

In his fourth paper Mr. Geikie sweeps the entire Glacial series of the Eastern side of England into correlation, not only with the Scotch Till, but with the Boulder-clay, both Upper and Lower, of the North-west of England. This he does, so far as I follow him, without any other grounds than that there are beds of "gravel, sand, mud and clay" in the Scotch Till. It is impossible, within the compass of these remarks, adequately to contest Mr. Geikie's views; but if the evidence of organic remains is to be regarded as worth anything, such a correlation cannot, I contend, be maintained.

I did, indeed, regard the Scotch Till as probably coeval with the "Great chalky clay;" but I am now disposed to think that even this clay is older than the Till, and to question whether the latter can be correlated with anything older in Yorkshire, Lincolnshire, or East Anglia, than the purple clay of the two first-named counties.

Geologists are aware that there is a Crag fauna in Britain, and that it is not identical with any recent assemblage of mollusca; and if the fauna of one set of Glacial beds shows a close approach to this Crag assemblage, and the fauna of another set shows no such approach, most geologists will, I think, agree that the former set is the older of the two. Now from the Lower Glacial sands of Norfolk there have been obtained 32 forms of mollusca, all of which, with one exception (*Tellina Balthica*), are Norwich Crag shells; and of this number three (or 9 per cent.) are not known living, viz., *Tellina prætenuis, Tellina obliqua, and Nucula Cobboldiæ.*[1] The Middle Glacial sands of Norfolk and Suffolk have yielded 81 forms of mollusca; all of which, with four, or perhaps five, exceptions, occur in some part of the Crag; and of these 81 there are 10 (or 12½ per cent.) not yet known as living, viz., *Trophon mediglacialis, Trophon Billockbiensis, Nassa pulchella, Pleurotoma assimilis, Cerithium tricinctum, Nucula Cobboldiæ, Astarte Burtinii, A. Omalii, Erycinella ovalis,* and *Tellina obliqua.*[2] From the Bridlington bed, which occurs in the Purple Clay of Yorkshire (a clay that rests upon the great chalky clay along the Holderness coast), 59 forms of mollusca have been obtained, of which 18 are unknown in any part of the Crag; and of these 59, two forms only (or rather more than 3 per cent.) are not known living, viz., *Nucula Cobboldiæ* and *Tellina obliqua.* The

[1] Some conchologists regard this shell as identical with *Nucula insignis* from Japan, and some with *N. Lyalli*, from Vancouver; while others, my father and myself among them, regard it as different from both. Even supposing, however, that one or other of these living *Nuculæ* be identical with *Cobboldiæ*, yet, for such a test as the comparison of the fauna of the East Anglian beds with that of the Scotch, it is much the same whether we regard the shell as not known living, or as living in so remote a sea as the North Pacific.

[2] The first four of these shells are new species, figured and described in the Supplement to the Crag Mollusca now awaiting the next issue of the Palæontographical Society. Some of these may probably turn out to be living forms, which would reduce the 12½ per-centage of extinct ones. *Trophon Billockbiensis* may possibly be the young of *Purpura tetragona*, an extinct Crag species.

Bridlington fauna, moreover, is peculiarly Arctic and North American, which is not the case with that of the Lower or Middle Glacial sands;[1] showing that the cold came on quicker than the mollusca could migrate with it.

Now, in the face of this, what are the pretensions to antiquity of the Scotch Till? Some intercalated beds of gravel, sand, mud, and clay, it is said. But intercalations of gravel, sand, and mud, occur in all Glacial clays, whatever be their age; and the Bridlington bed itself is merely a sandy intercalation in the body of the Purple clay, the Yorkshire coast showing many such. If the unfossiliferous character of the Scotch Till be relied on, I reply that this can be no ground to support the correlation claimed, but merely one that can be urged against its correlation with any other deposit. The Caithness Clay, however, is fossiliferous, and it has not been shown that this clay is distinct in age from the Scotch Till.[2] Mr. Croll did, indeed, attempt to show that it was the bed of some distant part of the North Sea, shoved into Caithness by an ice-sheet pressing down from Scandinavia, and filling the North Sea during the period of the Scotch Till; but if such were the case (which, however, I dispute), that would not remove the Caithness clay to a later period than the Scotch Till; for the fauna of this clay would either be that of the period of the Till, or of the immediately preceding period. Now the fauna of the Caithness clay, as obtained by Mr. Peach, and identified by Mr. Gwyn Jeffreys, comprises 66 forms of mollusca, of which 12 have not occurred in any part of the Crag; but the whole of which 66 occur as living, and living, moreover, on this side of the North American continent. The molluscan forms of the rest of the beds, both of the East and of the West side of Scotland (all of which are said to rest on the Till), are about 90 in number,[3] and all still living on this side of the North American continent, a considerable arctic facies pertaining to some of them; and of these no less than 26 are unknown in any part of the Crag, showing a yet greater departure from the Crag fauna, in accordance with their admittedly newer position of superiority to the Till. It cannot be urged that the affinity of the East Anglian beds with the Crag is

[1] The Middle Glacial fauna, however, affords indications of the incoming of this North American character in the occurrence of *Venus fluctuosa*, a Bridlington and North American shell not known in the Crag.

[2] Mr. Harmer and I examined the Scotch beds on the one side of the Highlands up to Cromarty, and on the other down to Glasgow. Of course, our examination was only a hasty and superficial one; but we could see nothing beyond the difference in the constituent material, due to the different character of the rock masses of the two areas, to separate the Boulder-clay of Cromarty from the Till of the region west of Glasgow. If I am not mistaken, the Cromarty clay is merely a continuation of the Clay of Caithness, and passes up into the Highland boulder sands about the Northern end of the Caledonian Canal, as the Till does beyond the Southern end.

[3] A larger number than 90 have been reported from these beds; but Mr. James Smith's lists are not trustworthy. I have taken my result from the revision of Mr. Smith's authorities, made by Mr. Crosskey, with the assistance of Mr. Jeffreys. If the other (unauthenticated) shells mentioned by Mr. Smith be added, however, the fauna would not be altered at all in character, nor the proportion of it occurring in the Crag be materially varied.

due to geographical causes, because the shells and shell fragments obtained by Mr. Jamieson in Aberdeenshire, although derivative in the gravels in which they occurred, clearly show that the Crag fauna once lived in Scotland, as we know that it also did still further North in Iceland; and, unless they have been wholly ploughed out by the ice, such Crag beds may still exist in Aberdeenshire, concealed by the Glacial formation.

If it be asked why should not the East Anglian Glacial beds occur in Scotland, and in the North and North-west of England, seeing that all these parts partook of the same depression, the answer appears to me a very simple one. When the period of maximum depression was attained (which, as it seems to me, was about the close of the contorted drift of Norfolk and Suffolk), the seaward edge of the ice-sheet extended as far as the west of those counties; and the material degraded by that sheet always travelling outwards to this edge furnished that which makes up this drift, which is principally red sandy mud, and the soft chalk of the East Anglian counties reconstructed into marl. After this deposit, the ice still further extended, scooping in so doing some of the East Anglian valleys out of this drift, and in South Suffolk nearly destroying it. At this period the deposit thus resulting from the shedding of the outward travelling material at the seaward edge of the ice was laid down beyond our present shores, that edge being somewhere out in the North Sea beyond the Suffolk and Norfolk coast. There then ensued a continuous recession of the ice, the succeeding Middle and Upper Glacial deposits going down into the valleys so excavated, without, so far as I can see, any elevation or oscillation of level having occurred until the Glacial period passed away, when, but not until when, emergence took place.[1] Wherever the ice-sheet rested, there I contend no deposit occurred, the material produced by its action incessantly travelling outwards to the ice edge, to be there deposited in the manner shown by Mr. Archibald Geikie in his Memoir in the Transactions of the Glasgow Geological Society for 1863, the material nearest the edge being deposited in an unstratified condition, from which it shaded off into first the streaked and obscurely stratified, and further out into the stratified condition. Thus I conceive the deposits succeeding the Contorted Drift have their sequence only partly in the vertical and mainly in the horizontal direction; the

[1] Mr. De Rance argues that the Lower Boulder-clay of Lancashire must have been deposited under a submergence of only about 100 feet beneath the present sea level, because in it are fragments which he traces from rocks to the north of it, which stand at elevations of only 300 feet. If, however, as I believe, the depression of that period, instead of being 100, was upwards of 1500 feet, the ice-sheet blocking out the sea and resting on these 300 feet elevations would convey fragments from them into the Boulder-clay then forming at the seaward edge of the ice. In a similar way, I now believe that the débris of the Chalk was carried into the great Chalky Clay when the highest elevations of the Chalk country were below the sea level, and that the second representation of my triple section, at p. 90 of the 24th Volume of the Geological Society's Journal, instead of being drawn to the 700 feet level, might, by thickening the ice-sheet, be drawn to the same 1500 feet level as the third, the resulting phenomena being due to the retreat of the ice alone without additional subsidence.

deposits having followed the ice edge as it receded, and the succeeding deposits having overlapped for a certain distance the preceding ones, but having been principally laid down upon places that were previously occupied only by ice,—a process which is, to my apprehension, very clearly exhibited by the Great Chalky Clay and its overlying purple clay, as we follow them northwards from the Humber towards that edge of the Eastern Moorlands which comes down to the coast at Scarborough.

During this recession of the ice, the mountainous districts which formed its chief gathering ground would be the last vacated by it; and, consequently, the deposits of and contiguous to those regions would be the latest in the whole sequence; and this physical hypothesis exactly accords with the palæontological evidence. Thus, the position of the Bridlington bed is at the horizon in the purple clay, where the chalk débris begins greatly to fall off; and as we ascend in the section of that clay, this débris ceases altogether, showing the eventual total release of the chalk from its icy cap, the débris from rocks lying nearer to the mountainous region than the Chalk Wold remaining undiminished. Contrary now to this, the East Anglian beds are equally chalky throughout, being chiefly made up of that material. The fauna of this Bridlington bed we see is decidedly newer than that of the East Anglian beds, while on the other hand, it is also clearly older than the Scotch Till (taking the Caithness clay as exhibiting the fauna of the Till period), tallying in this way with its intermediate physical position between the period of the East Anglian beds, when the ice-sheet extended over the chalk country into Norfolk and Suffolk, and the period of the Scotch Till and Caithness Clay, when the sheet had receded altogether from the Yorkshire Wold and other chalk districts, but still retained in its embrace the mountain districts of the North of England and of Scotland.

The East Anglian Lower Glacial therefore appears to me to form the nether, or older, extremity of the Glacial series, and the boulder sands and gravel of the mountain districts of Britain (whose fauna may be typified by that of the Moel Tryfaen bed) the upper, or newer, extremity; and as I take it that it was only near the ice-edge where deposits of such a thickness as would escape denudation during the subsequent emergence were formed, the newer terms of the series are thus unrepresented over the chief part of the areas where the older terms occur. The East Anglian Glacial beds are more distant than any others in Britain from the mountainous districts; and we should thus look for an older facies in any fauna they might furnish, than would be afforded by the Glacial beds of any other part of Britain. Having found the faunæ of these respective areas to present just this feature, are we then to shut our eyes to it and ignore its obvious bearing?

The Hessle beds do not, I contend, belong to the Glacial period at all. They followed the re-occupation of the terrestrial surface of this country by the Great Mammalia,[1] of the rivers by *Cyrena fluminalis*,

[1] *Elephas primigenius* and the horse are mentioned by Prof. Phillips as having occurred in abundance in the gravel below the Hessle clay at Hessle.

and of the seas by a molluscan assemblage, not merely all of living species, but one that differs in but a slight degree from that inhabiting the English coast near at hand. Mr. Harmer and I, in 1870, called attention to the character of the mollusca of the Lancashire middle sand, and to the possibility suggested by this character, that such sand, and the Upper Boulder-clay of the North-west of England, might belong to the Hessle group; for the mollusca of this middle sand (which I have now got from Wales, Cheshire, and Lancashire) is all of the same modern and contiguous English-coast character as that of the Hessle (Kelsea Hill) gravel, and of some Norfolk and Cambridgeshire post-glacial beds. In these two counties we have beds yielding a molluscan fauna of the same British-coast character,—viz., at March and several other places in that neighbourhood, at Hunstanton, and at several places in the Nar Valley,—and these occupy spaces from which the Glacial beds have been removed by denudation. From the knowledge since gathered by us as to these beds, and from the various evidence which has reached me from the North-west of England, and from the Severn valley, the possibility suggested by Mr. Harmer and myself in 1870 has grown in our minds into a probability of some strength. One fact which weighed with us adversely to this view was the limited thickness of the Hessle clay, and the comparative paucity and usually small size of the boulders in it; although one from this clay at Hessle, now in the Museum of the Literary and Philosophical Society at Hull, is of considerable size, and deeply grooved by parallel striæ. This, however, seems to me capable of a satisfactory explanation by reference to the geographical conditions attending the occurrence of this clay; for under the limited amount of submergence indicated by it, when compared with that under which the true Glacial deposits were accumulated, its nearest source of supply would be the higher parts of the Chalk Wold, then an island, and the next the island formed by the Eastern Moorlands—sources far more limited than the entire shed of one side of the Pennine chain. On the other hand, the lower elevations of the North-west of England, over which the Upper Boulder-clay of that region extends, would receive the entire material brought down by the glaciers occupying the valleys on the Western side of the Pennine Chain during that part of the Post-glacial period to which the Hessle clay belongs, when, as it seems to me, a high degree of cold returned upon Europe, bringing with it the Reindeer, and eventually also bringing about the extinction of the great Pachydermata. In a similar way the lower parts of North Wales, over which this Upper Boulder-clay and its underlying sand with modern British coast mollusca extends, and the Severn Valley, which is occupied with thick gravel-beds, yielding a similar modern British-coast molluscan fauna, would receive the entire material brought down by the glaciers occupying the valleys of the Welsh mountain district. In the North-east of England Mr. Rome and I, subsequently to the publication of our paper, traced an Upper Boulder-clay and underlying sand through the Vale of York into that of the Tees, which seemed to us to be a continuation of the Hessle clay and sand. The thickness presented by this clay was greater than that presented by the Hessle along the Holderness coast section, and it was usually much fuller of boulders. This feature, however, seems due to similar causes to those which account for the greater thickness of the Upper clay of the North-west, since, like the area of that clay, the Vales of York and of the Tees lie contiguous to the Pennine Chain, and would, in like manner to the Lancashire lowlands, be copiously supplied by material brought down by glaciers occupying its valleys. Information furnished me by Mr. Topley, of the Geological Survey, of sections in Northumberland, and the perusal of a paper by Mr. Howse relative to the beds of that county and of Durham, lead me to think that the Hessle Group is continued to the frontier of Scotland; but how far it may penetrate that part of Britain I have no information.

NOTICES OF MEMOIRS.

I.—Scheme for the Conservation of Remarkable Boulders in Scotland, and for the indication of their position on Maps. By D. Milne Home, F.R.S.E., F.G.S. From the Proceedings of the Royal Society of Edinburgh, 1870-71.

THE scheme which was set on foot last summer at Edinburgh, by Mr. Milne Home, for the preservation *in situ* of all the larger and more interesting Boulders of Scotland, has now assumed a definite shape. The paper in which the promoter discussed the subject, and ably demonstrated its importance, has been largely circulated among geologists and others North of Tweed, and, we believe, to some few in the North of England. Accompanying the papers are forms for recording, in a clear and uniform manner, the occurrence, size, position and nature of every remarkable boulder to be found in the parish or immediate neighbourhood of each observer. In this way a large array of facts will fall into the hands of Mr. Milne Home's Committee, which it will be their business to arrange, tabulate, and otherwise to mould into an available form. This work, if properly conducted, should be much more than a mere catalogue, and indeed would far outweigh in general value the actual preservation of the more noteworthy of the boulders themselves. It would throw light upon many points connected with the transport of Boulders in North Britain which are at present by no means clear to us, and all students of glacial phenomena would hail such a work as one of primary importance to them. One rule, however, which the Committee have printed at the head of their forms will, it seems to us, if adhered to, materially lessen the value of the undertaking, and that is embodied in the note limiting the stones to be registered to those above a certain number of tons in weight.

Now it is obvious that from a geological point of view a comparatively small block may in many cases be, from its position or composition, or from very distinct indications of its origin, much better worth noting and describing, and may furnish a far more instructive account of its travels, than an enormous monolite whose only merit is size. In cases of this kind the observers should be allowed to use their own discretion, and should record not only what is huge, but what is of value; and no doubt many of them will do so, notwithstanding the recommendation of the Committee to the contrary.

With regard to the preservation which will, we presume, follow this census of the Boulders, the subject connects itself naturally with the preservation of all our out-door objects of scientific and historical interest, and more especially with that of the so-called Druidic monuments, and of the numerous inscriptions and sculptures on natural rock-faces which are yearly disappearing from Britain under the brutal treatment of tourist roughs. That such a general curatorship of the monumental curiosities of the country is not unthought of, we have an earnest of in the purchase of Avebury by Sir John Lubbock. G. A. L.

March 12, 1872.

⁂ In connexion with the foregoing we append the following Note, which may prove of interest to those who are engaged in collecting information respecting Erratics.—Edit. Geol. Mag.

II.—Note on a Boulder near Old Cleeve, West Somerset.

By S. G. Perceval, F.G.S.

IT may be worth mentioning in your Magazine, that a large shrub-grown Boulder, seven or eight feet in height and several feet in circumference, formerly stood at the base of the hill, in a field to the west, immediately below New Barn, about a mile north of Old Cleeve Church. The rock composing it was felspathic or siliceous, exceedingly hard and compact, with angular fracture, of a dull yellowish colour, in parts mottled and striated of a greenish-black colour. Spherical concretions—of the same mineral character—with a concentric structure, some attaining the size of a cannon-ball, occurred in portions of the mass. There was no trace of organic remains, except some markings which might indicate the presence of organisms of a low type. According to Professor Ramsay, to whom I sent some specimens a few years ago—which are, perhaps, still at Jermyn Street—a rock of a similar description occurs in Carnarvonshire. From its position at the base of the hill, it might be supposed that the boulder had been deposited there at a time when the sea extended thus far. The coast at Blue Anchor is at present more than a mile distant. The occurrence of such a boulder in the neighbourhood was a circumstance quite unique. It was probably perfectly distinct from any formation in the West of England, and I have never seen a specimen of this kind, possessing so much interest, or whose origin was more unaccountable.

A smaller fragment of the same rock existed in a lane to the north of Old Cleeve Church, less than a mile distant from the principal boulder, and at about the same altitude.

I am sorry to say that the boulder has within the last few years been broken up for the purpose of mending the roads.

It may be worth mentioning in connexion with this boulder, that on the brow of the hill, in a field on the south of the Watchet Road, beyond the top of the hill descending to Blue Anchor, there was formerly a small boulder of quartz conglomerate projecting above the turf. Also at low-water mark off the commencement of the Alabaster Cliffs at Blue Anchor, a large round boulder of the same conglomerate, which probably had dropped from the top of the cliff, —as it has been gradually worn away—where it would have been in the same relative position with the previous boulder as regards the edge of the hill. These boulders may have been derived from a Carboniferous or older conglomerate. I am not aware of such a conglomerate in the New Red formation.

The Drift overlying the country is, in a great measure, derived from the Devonian rocks of the district, with a large intermixture of rolled quartz and hæmatite, which occur abundantly in the Brendon Hills. In the flat country, between Blue Anchor and Withycombe, there is a deposit of angular grauwacke drift, which, between Blue Anchor and the Pill (a small river), is overlain by a deposit of peat and remains of a forest, with occasional horns, etc., of red deer. This drift is exposed below the beach near the mouth of the Pill at Blue Anchor.

REVIEWS.

I.—Principles of Geology; or, the Modern Changes of the Earth and its Inhabitants considered as Illustrative of Geology. By Sir Charles Lyell, Bart. Eleventh and entirely Revised Edition. Murray. 1872.

II.—The Student's Elements of Geology. By the same Author. Murray. 1871.

IT has been well remarked that "there is no subject in the whole realm of human knowledge that cannot be rendered clear and intelligible if we ourselves have perfectly mastered it." We are, therefore, pleased to see our greatest authorities coming forward in answer to the increasing demand for a more popular teaching of science, and gladly welcome a new work, and a new edition of an old work, from the pen of Sir Charles Lyell.

I.—It is more than forty years since the Principles of Geology first appeared. In those days the true methods of scientific investigation were but ill understood, and Cuvier's Theory of the Earth was supposed to offer a sufficient explanation of the laws which have governed the formation of its crust. To examine the modern changes in the organic and inorganic world, to study the operations of Nature as far as they come under our direct observation, and then to compare the phenomena observed in the rocks with results of agencies which we have seen in operation, was a mode of treating the subject which recommended itself at once to the common sense and growing freedom of thought of the age.

For forty years has the progress of the science been watched, and the results of varied research carefully examined by one who can say in almost all branches of Geological inquiry, *Quorum pars magna fui.* Hence, while the general reader turns to Sir Charles Lyell's works for the most trustworthy account of what has been discovered by geology, and the inferences which may be drawn from those discoveries, the geologist turns to each new edition to see what is his judgment upon the more speculative questions which have been under examination since the appearance of his last edition.

Most of the readers of the Geological Magazine are familiar with and accept the Principles of Geology. We will therefore confine ourselves chiefly to some of the points which have been recently under discussion.

Sir Charles Lyell has made no change in the great Principles upon which he bases all his inferences. When we see phenomena precisely analogous to effects of which we know the cause, we must explain those phenomena by referring them to similar agencies to those which we now see producing precisely similar results—

Nec deus intersit nisi dignus vindice nodus.

But at the same time he shows us that it is part of Nature's plan by the accumulation of small effects, to produce great results.

Our author excludes from his inquiry all speculation as to what may have been the origin of the earth, and, holding that "Geology differs as widely from Cosmogony as speculations concerning the mode of the first creation of man differ from History" (p. 5), considers only the mode of formation of that portion which comes under our observation, and the conditions which must have prevailed at the several periods of its history. But while he passes by such questions as the nebular hypothesis, and the original fluid condition of our planet, as foreign to the scope of his work, there are astronomical questions of the greatest importance to geology which he goes into very fully.

It is a well-ascertained fact that there have been great vicissitudes of climate from very early periods. Here we have the fern and the vine, where boreal cold once prevailed; and there conditions are reversed, and we find that magnolias once bloomed within the Arctic regions.[1]

We need not pause long over the view which would account for observed changes of climate by the theory that the earth has been cooling down from an original high temperature. Sir Charles has expressly combated it (p. 296); and appealing to some calculations of Laplace on the length of the day, points out that "there are no positive proofs of a secular decrease of internal heat accompanied by contraction." In chap. vii. also he has given a clear refutation of the doctrine of the supposed former intensity of the igneous forces, which to a certain extent involves the same question. This does not imply that our author holds there has been no such gradual cooling down of our planet, but only that if there has, it must have gone on to such an extent before our history begins that we have no evidence of any perceptible difference within the period of which the rocks

[1] Student's Elements, p. 215.

offer us a record. But there is often evidence of the climate having been very different from what it is found to be in the same area now, though the change has sometimes been from warmer to colder, and sometimes *vice versâ.*

Our author discusses very fully the various astronomical causes which may have influenced climate. Perhaps the most important of these is the obliquity of the ecliptic, to which the phenomenon of the seasons is due. "Whenever," says Sir Charles Lyell, "the obliquity is greater than now, more of the arctic and antarctic regions would be exposed to a long night in winter, ... and under the opposite circumstances the reverse would take place." (p. 293.)

There is, however, another condition to be considered. The earth moves round the sun in an ellipse, having the sun in one of the foci, so that the earth is much nearer to it at one part of the year than at the other, and the excentricity of the orbit varies so that the difference between the distance when it is nearest and when it is farthest is much greater at one time than another. "Still, as the extreme amount of difference in the quantity of heat annually received, owing to such change in the minor axis, can never, by possibility, exceed the whole supply in a ratio of more than 1003 to 1000, it may, he [Sir John Herschel] says, be neglected in our geological speculations." (p. 273.)

Climate, however, depends not only upon the absolute amount of heat received, but also upon the manner in which it is distributed throughout the seasons; and if "the extreme of possible obliquity happened to combine with the maximum excentricity, and with geographical circumstances of an abnormal character, like those now prevailing in high latitudes, a greater intensity of cold would be produced than could exist without such a combination." (p. 293). It is therefore of great importance to consider which pole is turned away from the sun in aphelion under such conditions as here supposed, and astronomers show us that, owing to a combination of movements, the earth's path is so modified at intervals of a little more than 10,000 years, that the pole which was towards the sun when the earth was nearest is now towards the sun when the earth is farthest, and *vice versâ.* It is a matter of calculation when this combination of astronomical causes shall occur for either pole. Yet without "geographical circumstances of an abnormal character," the effect of such astronomical combinations would hardly be felt; the mean temperature would vary only within a very few degrees, and the climate but little. But if we follow our author, we shall find what a vast difference it makes in the climate of any region, whether it has land all round to absorb and give out again the heat of a tropical sun, or an ocean which will catch but little and slowly part with what it has caught; whether we have, collected round the pole, land to gather winter snow and prove a vast refrigerator when summer comes, or an ocean where little ice can be formed and little snow be gathered.

True to his Principles, Sir Charles Lyell examines what are the conditions which prevail on the earth now in hemispheres and along parallels of latitude, where we should, from astronomical causes, expect a uniform climate, and points out that "the climates of South Georgia and Tierra del Fuego, in the same latitude as well as in the same hemisphere, are at present so different that the former might be supposed to belong to a glacial period, while the latter, by its flowers and humming-birds in the winter, and the genera of marine mollusca in the adjoining sea, might indicate to the traveller as well as to some future geologist, such a temperature as has been spoken of as perpetual spring. This contrast is due to geographical causes, which if reversed, so that Tierra del Fuego became the oceanic island, would reverse the climate also." (p. 283.) Another striking example is given, p. 242, where we read that in Sandwich Island, in a latitude very nearly corresponding to the north of Scotland, during the hottest time of the year the whole country, from the top of the mountains to the brink of the sea-cliffs, was covered with snow many fathoms thick. So small is the difference of temperature produced directly by the astronomical causes, and so large the effects to be referred to geographical arrangements, even when not aided by astronomical combinations, or perhaps in spite of them. Mr. Croll has, however, suggested some more indirect causes of excessive cold under special circumstances of maximum excentricity, etc. He considers that all the moisture falling as snow, the summer sun, obscured by fogs, would be unable to remove it, and so there would be a storing up of polar ice from year to year to such an extent as even to derange the earth's centre of gravity, to say nothing of its withdrawing so much water from the ocean.

In reply to this, Sir Charles points out that without abnormal geographical conditions there could be no increase of cold from year to year; for instance, whenever a deep ocean prevailed at both poles there could be no storing up of ice; that there was no proof that the increasing heat of summer would not be sufficient to absorb all the aqueous vapour, p. 280; that when dry winds blow, snow wastes away like camphor, without melting, p. 289. But space will not allow us to dwell on these interesting questions any longer, and we will only refer our readers to chapter xiii.

Our author also investigates the origin and distribution of ocean currents and the temperature of the deep sea. This is also very important in its bearing upon ancient climatal conditions: for if we find Arctic cold prevailing at the bottom of Tropical oceans, that must teach us to be cautious in inferring too hastily from the presence of certain forms of life which are now found only in water of a higher or lower temperature, that the general climatal conditions must have been very different from what we now find them in the same area. How far a fuller knowledge of the operations of ocean currents may remove some of the difficulties of explaining the occurrence of tropical plants within the Arctic circle or the dwarfed forms of life of many ancient formations, we must wait to see.

II. We learn from the preface to the Student's Elements of Geology, that it is founded upon the author's earlier work, the Elements of Geology, which he has abridged by omitting many points of speculation which he had felt bound to go into more fully in his former work. But new discoveries had to be noticed, new theories considered, to bring the book up to the day, and it had to be entirely recast.

Several important changes bearing upon the classification of both the older and newer rocks may be noticed; sometimes involving a change in the brackets by which we group together the strata according to the evidence we have of the continuity or discordance of the conditions which prevailed at successive periods; and sometimes arising from a more detailed subdivision of beds which have been better worked out. For instance, the discovery of a rich fauna in rocks of Cambrian age in North and South Wales, as well as on the Continent, has called for a new nomenclature in that part of the series. The reconsideration of the evidence for drawing the line between Lower and Upper Silurian in the middle of the Llandovery rocks has led our author to bracket those formations together, and draw the strongest line provisionally at the base of the Lower Llandovery. (p. 452.) "I formerly," says Sir Charles, "adopted the plan of those who class them as Middle Silurian, but they are scarcely entitled to this distinction, since, after about 1400 Silurian species have been compared, the number peculiar to the group in question only gives them an importance equal to such minor subdivisions as the Ludlow or Bala groups. I therefore prefer to regard them as the base of the Upper Silurian, to which group they are linked by more than twice as many species as to the Lower Silurian. By this arrangement the line of demarcation between the two great divisions, though confessedly arbitrary, is less so than by any other." (p. 452.) It does not matter so much whether they are grouped together as a Middle Silurian or as a distinct division at the base of the Upper Silurian, for our divisions are well known to be not of equal value; but it is very important to place these rocks together in one group, instead of making the Lower Llandovery belong to one great division of the series, and the Upper Llandovery to another.

After a re-examination in the field of the rocks of Devon, our author speaks of them still as "the marine type of the British strata intermediate between the Carboniferous and Silurian." (p. 431.) As long as we cannot clearly correlate either newer or older Devonian beds with rocks also known to be "intermediate between the Carboniferous and Silurian" on the other side of the Bristol Channel, we may well be content to wait for further evidence before we come to a definite conclusion as to whether or not we have in Devonshire the exact equivalent of the great mass of Old Red which succeeds the Tilestones conformably in South Wales; or whether we have beds homotaxially related to the Lower Carboniferous with its Lower Limestone shale in one area, and rough conglomerate in another. Possibly these beds, being more closely allied to the Carboniferous than to the true Old Red, were deposited in the Devonian area while a wave of depression was travelling from south to north, thus making the deposits of the southern district of earlier date. At any rate, the interval between the Silurian and Carboniferous is so enormous that we should have plenty of room for all the deposits, even on the extreme supposition that all the so-called Devonian was newer than nearly all the so-called Old Red.

Much valuable new matter has been introduced into the description of the Lower Cretaceous rocks, and a more full discussion of the age of the Blackdown Beds is given at p. 277.

We need go no further than to notice how all the newest evidence to be obtained as to the fossil flora of Miocene and other periods, and the many new facts and theories bearing upon glacial phenomena, have been weighed, and the results clearly stated, to show that we have in the "Student's Elements" a most valuable epitome of the present state of our knowledge of stratigraphical geology.

In conclusion, we will only say that those who would learn the true method of working out the great problems of Geology should study that most readable and philosophic work The Principles, and those who would learn what are the data upon which the story of the ancient earth has been founded should avail themselves of that most concise and clear summary, the Student's Elements.

III.—The Micrographic Dictionary: a Guide to the Examination and Investigation of the Structure and Nature of Microscopic Objects. By J. W. Griffith, M.D., etc., and Arthur Henfrey, F.R.S., etc. Third edition, edited by Dr. Griffith, assisted by the Rev. M. J. Berkeley, M.A., and Professor T. Rupert Jones, F.G.S. 8vo. Van Voorst, London. Parts I. to VI. September, 1871, to February, 1872.

We must draw the attention of our readers to the "Micrographic Dictionary," now in course of publication, as very useful to the geologist, whether naturalist or physicist, whether palæontologically or mineralogically inclined. Besides the habitual use of the pocket-glass or hand-lens, recourse must often be had now-a-days to a good microscope, to determine the structure of rocks and the nature of minute fossils; and, for comparison with these, chemical products and living organisms have to be microscopically studied with equal care and exactness. Students and workers have an extensive choice of manuals, text-books, and introductions to the use of the microscope, and for the recognition of microscopic objects, in the numerous books by Carpenter, Quekett, Griffith, Hogg, Lankester, and others. These authors have classified the natural objects under examination, and the first-named has given a chapter on the application of the microscope to geological investigation. A very wide field, however, is open for histologists in "microgeology," or "clinology," as the study of rocks by means of the microscope has been termed. The labours of Ehrenberg, richly illustrated in his "Mikrogeologie"; the enthusiastic work of Schafhäutl; the systematic researches of Delesse, Naumann, Sorby, David Forbes, and Allport; the occasional contributions of De Beaumont, Bischoff, Scheerer, Brewster, Phillips, Reade, Bryson, Dawson, and others, at home and abroad,—all indicate the path by which the microgeologist is to advance towards a clearer knowledge of strata, both altered and unaltered, and of igneous rocks of various ages, different sources, and manifold conditions. The special organisms, too, that occur in clays and sandstones, and that make up tripoli, coal, and limestones, have to be fully worked out, and explained by the structure of existing organisms. Many an interesting point is waiting for elucidation—such as the modes of origin of flint, hornstone, and chert in limestones; the part played by various plants and their several organs in supplying matter for coals and lignites; the nature and function of Coccoliths, so widely spread and so long persistent, according to Huxley and Guembel; the discrimination of doubtful bones, whether of reptile, bird, or mammal; and many other objects—as Conodonts, Eozoon, Stromatopora, Graptolites, and fossil Sponges—are open to further illustration under the microscope; and the fossiliferous limestones will supply material for a life of study to a microscopist, like the great Ehrenberg, equal to the elaboration of these wondrous "halibioliths," or marine rocks of organic origin. He must be patient and acute, neither jumping at hasty conclusions, nor caught by partial analogies and false similitudes. He must have an educated hand and eye, with the experience of others at his elbow. The Introduction of the "Micrographic Dictionary" will go far to instruct him how to observe, and the body of the work will prove a faithful guide to the expositions already made of living and extinct organisms, of much indeed of both animate and inanimate materials that he is likely to meet with in his researches.

One of the most remarkable instances in which the microscope has been successfully applied to the elucidation of rock-structure is the study of crystals in granites and lavas, by Mr. H. C. Sorby, F.R.S., in 1858; and the concluding words of his memoir [2] on the subject are so apt and truthful that we reproduce them as a wholesome stimulus to microgeologists:

"These results are all derived from the study of the microscopical structure of the crystals; but my own observations in the field lead me to conclude that they agree equally well with the general structure of the mountains themselves, and serve to account for facts that could not have been satisfactorily explained without the aid of the microscope. And here I cannot but make a few remarks, in conclusion, on the value of that instrument, and of the most accurate physics in the study of physical geology. Although with a first-rate microscope, having an achromatic condenser, the structure of such crystals and sections of rocks and minerals as I have prepared for myself with very great care can be seen by good daylight as distinctly as if visible to the naked eye, still some geologists, only accustomed to examine large masses in the field, may perhaps be disposed to question the value of the facts I have described, and to think the objects so minute as to be quite beneath their notice, and that all attempts at accurate calculation from such small data are quite inadmissible. What other science, however, has prospered by adopting such a creed? What physiologist would think of ignoring

[2] Quart. Journ. Geol. Soc., vol. xiv., p. 497.

all the invaluable discoveries that have been made in his science with the microscope, merely because the objects are minute? What would become of astronomy, if everything was stripped from it that could not be deduced by rough calculation from observations made without telescopes? With such striking examples before us, shall we physical geologists maintain that only rough and imperfect methods of research are applicable to our own science? Against such an opinion I certainly must protest; and I argue that there is no necessary connexion between the size of an object and the value of a fact; and that, though the objects I have described are minute, the conclusions to be derived from the facts are great."

REPORTS AND PROCEEDINGS.

Geological Society of London.—February 21st, 1872.—Prof. Ramsay, F.R.S., Vice-President, in the Chair.—The following communication was read:—"Migrations of the Graptolites." By H. Alleyne Nicholson, M.D., F.R.S.E., F.G.S., Professor of Natural History and Botany in University College, Toronto.

The author commenced by stating that the occurrence of the same species of marine animals in deposits in distant areas is now generally regarded as evidence that such deposits are not strictly contemporaneous, but rather that a migration from one area to another has taken place; this migration he thought would probably in many cases be accompanied by modification. Applying these principles to the Graptolites, he endeavoured to show in what directions their migrations may have taken place.

He excluded from the family Graptolitidæ the genera *Dictyonema*, *Dendrograpsus*, *Callograpsus*, and *Ptilograpsus*, and stated that the family, as thus limited, extended from Upper Cambrian to Upper Silurian times. The earliest known Graptolites were those of the Skiddaw Slates, which he thought would prove to belong to the Upper Cambrian series. The Skiddaw area he considered to extend into Canada, where the Quebec group belongs to it. Genera of Graptolites belonging to this area are represented in Australia, and this the author regarded as indicative of migration, but in which direction was uncertain. Having discussed the forms of Graptolites characteristic of the deposits in the Skiddaw-Quebec area, the author proceeded to indicate the mode in which the family is represented in the areas of deposition of the great Silurian series, namely, the Llandeilo areas of Wales and Scotland, the Coniston area of the North of England, the Gala area of South Scotland, the Hudson-River area of North America, and the Saxon and Bohemian areas, giving under each of these heads a list of species, with indications of their probable derivation.

Discussion.—Mr. Etheridge commented on the importance of Dr. Nicholson's paper, and on the difficulties attending the study of the Graptolitidæ. The migration of these organisms appeared to him to be very difficult to establish, especially in connexion with their extension both eastwards and westwards.

Mr. Hughes believed that if we could discover the original of any species, we should see a small variety appearing among a number of forms not very different from it, and from which it had been derived; but when the variety had prevailed, so as to be the dominant form, we were far on in the history of the species; that it was a great assumption to fix upon any bed we now know as representing the original source of any group; that we know too little about the chronological order of the geological divisions referred to to reason with any safety on the migration of Graptolites from one area to another; that the term *Lower* Llandeilo, for instance, was very unsatisfactory as used in the paper; there was nothing lower than the Llandeilo Flags at Llandeilo; and where older beds occurred in Scotland and elsewhere, it was not at all clear that the equivalent of the Llandeilo Flags was present at all. He differed also altogether from the author as to the position of the Dufton Shales, and criticized the views of the author as to the range of some species. He thought that M. Barrande's theory of the colonies was borne out by the study of the Graptolites, but that we had not sufficient data to speculate as to the areas in which they made their first appearance, or the order of their geographical distribution.

Prof. Duncan observed that at the present time there was, among other forms, quite as great a range of species as that of the Graptolites pointed out by the author. Having looked through all the drawings of Graptolites that he could meet with, he had found none whatever that were accurate; and he had moreover never in any specimens discovered such cups or *calices* between the serrations as were always attributed to these organisms. From all he had seen he was led to the conclusion that the projections on the Graptolites bore the same relation to the central stem as those of some of the Actinozoa. These latter also, like the Graptolites, seemed to prefer a muddy sea. Professor Duncan also suggested that the Graptolites were really the remains of the filiform polypiferous parts of floating Hydrozoa.

Prof. Morris regarded the paper as mainly suggestive. It was on all hands agreed that there were in Britain two principal zones in which graptolitic life was most abundant; and the same held good in America. Both these seemed to be homotaxially related. M. Barrande had long since pointed out the probable emigration of many of the Bohemian species from the British area; and there could be no doubt of there being many species common to Europe, America, and Australia. This afforded strong evidence in favour of some such theory as that of migration. He cautioned observers as to taking careful notice of the manner in which Graptolites are presented in their matrix; for when seen from three different points of view, they exhibited such differences that three species might be made from one form of organism.

Mr. Gwyn Jeffreys mentioned the wide distribution of marine Hydrozoa by means of winds and currents, as illustrative of the history of Graptolites, the dispersion of which might have arisen from similar causes, and not from migration.

Mr. Prestwich commented on the uncertainty of our knowledge with regard to Graptolites, and consequently regarded speculation on the subject of their migration as premature. He instanced *Cardita planicostata*, which was formerly regarded as having originated in the Paris basin and come thence into England, but which had since been found in far earlier beds in Britain; so that the presumed course of its migration has been reversed.

Mr. Hicks remarked that the rocks referred by the author to the Upper Cambrian were in reality the lowest of the Silurian series, and that the Graptolitidæ were exclusively a Silurian family.

Mr. Hopkinson also made some remarks both on the distinction of different species of Graptolites and on their distribution. He regarded the Quebec area as that in which these forms had originated.

The Chairman commented on the great want of accord among those who had studied Graptolites, not only with regard to their structure, but to their distribution in different horizons. He thought that the suggestion of the author, as to modification of form during migration having taken place, seemed to throw some light on the subject. He could not regard two districts now only separated by the Solway Firth as constituting two geographical areas so distinct that the occurrence of the same species in both could with propriety be held to be due to migration. The phenomena in the other cases seemed to him quite as much in accordance with distribution from some common centre as with migration along any line connecting two spots where Graptolites are now found. He thought that the recurrence of these forms on different horizons in Cumberland was to be accounted for by the fact that most of the rocks which intervened between the shales containing these organisms were merely subaërial volcanic beds, on which, after submergence, these muddy shales had been deposited.

Geologists' Association.—1st March, 1872.—Professor Morris, F.G.S., Vice-President, in the Chair.—1, "On the Geology of Hampstead (Middlesex)." By Caleb Evans, Esq., F.G.S.—The author described the deposits which had been exposed from time to time during the last few years in and near Hampstead. The principal excavations noticed were the several drainage works near Child's Hill, on Hampstead Heath, and in Frognall Lane, and the tunnel on the Midland Railway under Haverstock Hill. It appeared from these sections that the Lower Bagshot Sand which caps the hill passes downwards into a dark sandy clay about fifty feet thick, abounding with fossils, especially *Voluta nodosa* and *Pectunculus decussatus*. The *Pectunculus* bed passes down into the London Clay of ordinary character, which forms the lower part of Hampstead Hill. The author noticed the great changes in physical geography which must have taken place during the time that intervened between the deposition of the Woolwich Series and that of the Lower Bagshot Sand. He considered that remains of the Glacial deposits probably exist on the north side of the hill. The position of these deposits on an eroded surface of the London Clay showed the large amount of denudation that had taken place prior to the Glacial epoch. The author, in conclusion, directed attention to the existing valleys around and to the north of Hampstead, which he considered had been formed by means of the springs issuing from the water-bearing Eocene sand and the Glacial gravels.—Mr. A. Bell thought the leaf-beds of the Middle Eocene indicated freshwater conditions.—Mr. H. Woodward considered the presence of *Xanthopsis* in these beds evidence of marine or estuarine origin. He pointed out the great value of the maps and sections exhibited by Mr. Evans.—Professor Morris spoke of the foreign equivalents of the London Eocenes, during the deposition of which great changes of level took place. Though there are no traces of the Woolwich beds in the Belgian area, these deposits are represented near Epernay in France, while the London Clay forms a considerable area in Belgium. The patches of London Clay on Salisbury Plain indicate the extension of the Lower Eocene sea over that area, and Bracklesham species are found at Chertsey. With respect to the Glacial deposits, the Professor considered their importance to Middlesex very considerable, and thought it not improbable that the towns of Barnet, Hendon, and Finchley owed their origin to the presence of these deposits. The physical features of the country north of Hampstead are different from those south of that place, and this difference is due to the Glacial deposits. Though the valleys of the district have been formed, as we now see them, by the rivers, their formation commenced during the rise of the land from the sea.

2. "On a Recently-exposed Section at Battersea." By John A. Coombs, Esq.—This was a brief description of a section exposed at the works of the London Gas Company now in progress near Battersea. The Thames valley-gravels are cut through, and several feet of the London Clay are exposed. The gravels, which show much false bedding, yield mammalian remains, but the *Cyrena*

fluminalis has not been found. Several species of Mollusca have been found in the Clay, but the most abundant fossil is the *Pentacrinus sub-basaltiformis.*—Mr. Hudleston noticed that the gravels exposed at the Law Courts site in the Strand were much more ferruginous than those at Battersea, and that the Clay immediately underlying the gravels was altered in colour and character to a much greater depth at the former than at the latter section.—Mr. A. Bell thought the *Cyrena fluminalis* would never be found in these beds at Battersea, as it belongs, he considered, to beds of a different age.

CORRESPONDENCE.

THE SOURCE OF VOLCANIC PRODUCTS.

SIR,—In the last number of the GEOLOGICAL MAGAZINE, the writer of a notice on the re-issue of Mr. Scrope's work on Volcanos observes, that the strongest argument in favour of a *common source* for all volcanic matters is the one brought forward by Mr. David Forbes, "That the volcanic rocks, taken from any quarter of the world, possess an absolute identity in chemical and mineralogical composition."

Now, admitting the fact that basalts, trachytes, obsidian, etc., are essentially the same, from whatever part of the world they may be collected, and that the statement would be equally true of the older rocks, I am quite at a loss to perceive in what way such facts are more favourable to one rather than to the other of the two prevailing views.

Those views are, either, that volcanic matter is now being ejected from the still fluid central portion of the globe; or, that the molten matter exists in pockets or reservoirs, at varying but still moderate distances from the outer surface. On the latter supposition, the molten matter would be supplied by the fusion of surrounding and underlying rock-masses, or by the repeated falling-in and re-fusion of previously erupted materials, none being actually forced up from an imaginary central mass of fluid.

Now, it will scarcely be denied that the rocks forming the accessible portions of the earth's surface are the same all the world over, and have been so from the commencement of the Laurentian series at least; how much longer no one can say. Limestones, sandstones, shales, and other fragmental rocks, are everywhere the same, and there is no evidence to show, or reason to suppose, that the materials forming the earth's crust at still greater depths differ from each other in different parts of the world. It should be remembered that the elements entering into the composition of rock-masses are extremely limited in number, almost universally distributed, and occur in the eruptive equally with the stratified series; the former may well have been derived from the fusion of the latter, just as these, undoubtedly, owe their origin in many cases to the abrasion and degradation of older igneous masses.

It would appear, therefore, that a general uniformity of composition in volcanic products would necessarily result from either source of supply, and that if the central-fluid theory is to be maintained, it must be for other and less fanciful reasons than those hitherto adduced. I quite agree with the remark that it has been rather *assumed* that geologists believe in a fluid interior with a solid crust. They probably believe nothing of the kind, for, like other inquirers accustomed to scientific investigations, they are not disposed to adopt a belief, unless it be grounded on well-ascertained facts; and as there now exists but little faith in mere opinions of great authorities, it would appear that in the present phase of the question, the most satisfactory state of mind would be one of pure scepticism.

S. ALLPORT.

CORRELATION OF THE SCOTCH AND ENGLISH DRIFTS.

SIR,—As I have probably devoted more time to the examination of the drifts of the N.W. of England than any other observer, a few remarks from me seem to be called for by Mr. James Geikie's article in your last number. While very willing to acknowledge the great value of his contributions to Post-tertiary geology, I cannot agree with him in regarding all the drifts of the above area as subordinate varieties of one great formation; for the more these deposits are investigated, the more one becomes convinced of the classificatory value of the well-defined and more or less persistent sub-divisions they present.

The blue clay of the W. Riding of Yorkshire, Cumberland, and N. Wales, is not only distinct in colour, and in the character of most of its included stones, from the other clays, but it must have been subjected to great denudation, leaving a deeply-undulating or hummocky surface, before the lower brown clay was deposited. The latter (though it embraces a considerable variety) differs in its general colour, composition, and relative proportion of local and erratic stones, the number of large boulders, etc., from the upper clay; and its surface generally undulates as if it had been extensively denuded; while the surface of the upper clay is in most places a dead flat. The gravel-and-sand formation between the two clays is not a series of intercalations, but as persistent a deposit as either of the clays. It has to a great extent been derived from local rocks, and the number of erratic stones it contains is much smaller than in the clay above or below. Its surface must have been deeply denuded before the upper clay was deposited, as Professor Hull and Mr. De Rance have shown. In the neighbourhood of hills it generally rises up from beneath the upper clay, and forms a series of knolls or ridges. There are few sand-and-gravel knolls that are not capped with decided Upper Boulder-clay,[1] or show indications of having once been more or less covered with this clay. I do not believe that in the area under consideration there are any sand or gravel knolls overlying decided Upper Boulder-clay, though they may occasionally come above a subordinate clay bed of the middle drift, or a thin bed

[1] In the neighbourhood of Oswestry there are striking instances of high and abrupt gravel-and-sand knolls capped with upper boulder-clay.

of local Lower Boulder-clay. The more the subject is investigated, the more one becomes convinced that the Upper Boulder-clay is the newest glacial or *interglacial* deposit in the N.W. of England.

The shell-bearing gravel-and-sand around Macclesfield, which according to Mr. Sainter (Geol. Mag., Vol. II., pp. 366, 368) ranges from 600 to 1200 feet above the sea-level, is I believe an upward extension of the middle drift of the plain of Cheshire. The deposit on Moel-y-Tryfan is not so finely stratified, and the stones are not so much rounded as in the gravel at lower levels; but it agrees with the gravel-and-sand of Anglesey in the large boulders being found at its base (though a few are scattered through its mass), and with the Cheshire and Lancashire middle drift in the character of many of its erratics, including Eskdale and Criffell granite, chalk-flints, etc. Mr. Darbishire says it is capped with clay (Geol. Mag., Vol. II., p. 295); though this I missed seeing.

The following is the sequence of the drift deposits of the N.W. of England and a part of Wales (order descending):—

Red clay, with grey or blue partings; rather few stones and exceedingly few large boulders; more or less marly in its lower part; extensively used for bricks. Maximum thickness unknown.

Gravel and sand, with subordinate beds of clay and loam. Maximum thickness in Cumberland 120 feet; at Gresford, near Wrexham, 150 feet; at Kersal Moor, Lancashire, 200 feet (Hull).[1]

Madder-brown clay, with subordinate beds of laminated loam, seams, pockets, and lenticulations of sand; numerous stones, and at intervals many large boulders; vertical or oblique fractures; often rudely stratified; graduating into a still harder, more gritty, and stony clay, with a tendency to arched stratification, in the neighbourhood of the hills (Pinel); in general not well adapted for bricks. Maximum thickness at Lindal, Furness, 120 feet.

Blue or greyish-blue clay, with many stones and at intervals many boulders. Maximum thickness at Colwyn, N. Wales, not less than 60 feet.

The above drifts have been found to be shell-bearing with the exception of the blue clay and the pinel. The best sections may be seen on the sea-coast.

D. Mackintosh.

MR. W. S. MITCHELL ON THE "DENUDATION OF THE BATH OOLITE."

Sir,—I believe Mr. Mitchell is of opinion that the hills of Bath Oolite were simply old coral-reefs, and did not owe their form to denudation. (See Quart. Journ. Geol. Soc., 1871, vol. xxvii., p. 228.)

I was staying near Bath in the Spring of 1869, and discovered, in a shallow excavation on the left of the road on Kingsdown, beyond Bathford, some beautiful specimens of Oolitic Corals—the finest which have been obtained from the neighbourhood of Bath—the best of which I gave to Mr. Charles Moore, for the Bath Museum. They consisted of several genera and species, and occurred at one portion of the excavation; the space which they occupied being a few yards across, and appearing to be a section of a small coral reef, bounded on each side by the usual limestone. It is possible this bed increases in width, vertically.

Corals appear to be of rare general occurrence in the Bath hills;

[1] In the Vale of York this formation is associated with deposits of finely laminated clay of various colours.

and the coral-reefs, I should think, were merely local, and of limited extent, and do not constitute their mass, which consists, probably, merely of the contents of an Oolitic sea.

HENBURY, BRISTOL, *March* 8, 1872. SP. GEORGE PERCEVAL.

OBITUARY.

CALEB BURRELL ROSE, Esq., F.G.S., F. R. Med. and Chirur. Soc. Lond.[1]

WE regret to have to record the loss of C. B. Rose, Esq., M.R.C.S., F.G.S., of Great Yarmouth, Norfolk. Mr. Rose was born at Eye, in Suffolk, 10th February, 1790, and spent the greater part of his life in the active duties of his profession, as a medical man, at Swaffham, in Norfolk. His leisure hours were, however, devoted from an early period to the study of geology.

He was a contemporary of, and fellow-labourer with, the late Mr. Samuel Woodward, Author of an "Outline of the Geology of Norfolk," published in 1833, etc., etc. Mr. Rose published a "Sketch of the Geology of West Norfolk" in the "London and Edinburgh Philosophical Magazine and Journal of Science," 1835, vol. vii. pp. 171, 274, 370, and 1836, vol. viii. p. 28 (published also in a separate form, Swaffham, 1836); a treatise "On the Cretaceous Group in Norfolk," (Geologists' Association, November 8th, 1862); besides papers published in the Quart. Journ. Geol. Soc. 1846, vol. ii. p. 32; the British Association Reports, Belfast, 1852; Cambridge, 1862; Norwich, 1868; the Transactions of the Microscopical Society; the GEOLOGICAL MAGAZINE, 1864, Vol. I., p. 92, "On Cycloid Fish-scales in the Oolitic Formation;" 1865, Vol. II., p. 8, "On the Brick-earth of the Nar;" 1867, Vol. IV., p. 29, "On the Cretaceous Groups of Norfolk and Kent."

Mr. Rose showed the true position of the Red Chalk of Hunstanton, and that the "Carstone" should be referred to the Cretaceous and not to the Oolitic series. The curious deposit known as the "Nar Valley Clay," or "Brick-earth," was explored by Mr. Rose, who collected a large series of the shells found in it, which proved it to be one of the latest marine deposits in Norfolk, later than the Crag or even the Boulder-clay series.

After retiring from practice, he resided at Yarmouth, where he drew the attention of Mr. Prestwich to the remarkable well-section at Sir E. K. Lacon's Brewery, in which the London clay and Woolwich and Reading series were passed through. (See Quart. Journ. Geol. Soc., Nov. 1860.)

Mr. Rose also discovered the interesting fossiliferous bed at Aldeby, which has yielded so large a collection of fine Crag-shells.

He was most active in promoting the successful reception of the British Association at Norwich, in 1869; and it is to be feared he never recovered from the exertions he made at that time.

He was elected a Fellow of the Geological Society of London in 1839, and died at Yarmouth, on 29th January, 1872, in his 82nd year.

Previous to his decease, Mr. Rose gave his collection to the Norfolk and Norwich Museum.

[1] For some of these particulars we are indebted to J. Prestwich, Esq., F.R.S., V.P. Geol. Soc., and to T. G. Bayfield, Esq., of Norwich.

HENRI-SÉBASTIEN LE HON.

We also regret to record the loss of Monsieur le Chevalier Le Hon of Brussels, who died at San-Remo, Italy, on the 31st January last. M. Le Hon was *Major pensionné* and formerly Professor of the Military School in Brussels, and a Chevalier of the Order of Leopold, and was decorated with the Iron Cross. He was a member of the Geological Society of France; a Corresponding Member of the Imperial Institute of Geology of Vienna; of the Italian Society of Natural Sciences of Milan, etc., etc.

His chief published work, which is of considerable merit, is entitled: "L' homme Fossile en Europe," Brussels, 1867, of which two editions have appeared.

FRANÇOIS-JULES PICTET—DE LA RIVE.

Geological Science has sustained a heavy loss in the death of Monsieur François-Jules Pictet, who died at Geneva, on the 15th March last, in his 63rd year.

M. Pictet was Professor of Geology and Palæontology in the Academy of Geneva, and also a National Councillor.

He was elected a Foreign Correspondent of the Geological Society of London in 1863.

His published memoirs exceed forty in number. He was one of the editors of the "Archives des Sciences physiques et naturelles," published at Genèva, 1846, et seq.

His greatest works are the following:—

I. "Traité Elémentaire de Paléontologie, ou Hist. Nat. des Animaux Fossiles," in four vols. 8vo., 1844—46, pp. 1766, and 73 plates.
Second Edition:—Text in four vols. 8vo., 1853—57. Atlas 4to., with 77 pages and 110 plates.

II. Materiaux pour la Paléontologie Suisse, ou recueil de monographies sur les fossiles du Jura et des Alpes.
1st Series: 11 parts, Genèva, 1854—58. 4to., pp. 184, plates 23.
2nd Series: (by MM. Pictet & Campiche) 1858—60. 4to.
1*st Part*, pp. 380, 2 maps, and 43 plates. (With a *separate Folio Atlas*, containing 7 large plates of Fossil Fishes.)
2*nd Part* (by MM. Pictet and Loriol), pp. 54, 2 maps, and 11 plates.
3rd Series: (by MM. Pictet & Campiche) 1861—64. 4to. pp. 752, 55 plates. (With a *Supplement* on the Reptiles and Fishes of the Jura of Neufchatel, par MM. Pictet et A. Jaccard, 1860. 4to. pp. 88, plates 19.)
4th Series: (par MM. Pictet et Campiche) 1864-67, 4to. pp. 558, plates 41. (With a *Supplement* by MM. Pictet and Loriol: 1868, 4to. pp. 110, and 9 plates.)
5th Series: (par MM. Pictet et Campiche) 1868-71, 4to. pp. 352, plates 55.

Geological Survey of the United Kingdom.—Since the death of Sir Roderick I. Murchison, Bart., which took place on the 22nd of October, 1871, the post of Director-General of the Geological Survey of the United Kingdom has remained vacant.

Early in March Professor Andrew C. Ramsay, LL.D., F.R.S., V.P. Geol. Soc., Director of the Geological Survey for England and Wales, received the appointment of Director-General for the United Kingdom; and shortly afterwards Henry W. Bristow, Esq., F.R.S., F.G.S., Senior District Surveyor, was promoted to the post of Local Director. The appointment of Director of the Royal School of Mines, formerly held by the Director-Gen. of the Geol. Survey, is, we understand, to remain for the present in abeyance, pending the consideration of the Government to remove that Institution from Jermyn-street to South Kensington. The promotion of Prof. Ramsay and Mr. H. W. Bristow has given the greatest satisfaction to all the members of the staff and to the Geological world at large.

A. T. Hollick del. et lith. Mintern Bros. imp.

ANNUAL REPORT

OF THE

GEOLOGISTS' ASSOCIATION

FOR

1871.

GEOLOGISTS' ASSOCIATION.

Report of the General Committee for 1871.

The General Committee of the Geologists' Association have great pleasure in congratulating the members on the continued prosperity and progress of the Association.

During the past year the Papers have equalled in interest and importance those presented to the Association during preceding years, and your Committee have peculiar satisfaction in finding that the attendance at the evening meetings has been large, and the discussions animated and interesting.

The communications on local geology, or the geology of the neighbourhood of London, have been of great interest, and will, without doubt, prove of permanent value.

The visits to the three great Museums of the Metropolis, the British Museum, the Museum of Practical Geology, and the Museum of the Royal College of Surgeons, were in each instance participated in by a large number of members, who conspicuously indicated their appreciation of the great advantage of inspecting specimens under the guidance of Professor Morris, Mr. Etheridge, Mr. Carruthers, Mr. Henry Woodward, and Professor Tennant, who most kindly gave, at the Museums, explanatory lectures. Your Committee feel under great obligations to the authorities of these noble homes of science for their courtesy in giving facilities for the visits of the Association.

A similar lively interest on the part of the members has been taken in the Excursions of the Association, which, during the past year have been of great value, and almost uniformly very successful. To the gentlemen who have contributed their local knowledge, and kindly acted as directors of the several excursions, the warmest thanks of the Association are due, for to them is principally owing the success of the excursions.

Your Committee have again the pleasure of offering, on your behalf, the thanks of the Association to Professor Morris, for the great assistance he has rendered the Association by his lectures in the museum and in the field, as well as by his instructive companionship during the excursions.

To Professor Phillips, the Rev. T. G. Bonney, Professor Buckman, the Rev. P. B. Brodie, Mr. Henry Woodward, and Mr. Harry Seeley, the thanks of the Association are also eminently due.

The Excursions have enabled the members of the Association to examine the following formations, and thereby make themselves acquainted with the Petrology and the Palæontology of these interesting groups of strata :—

KEUPER—Warwick.
LOWER LIAS—Harbury and Wilmcote.
MIDDLE LIAS—Yeovil and South Petherton.
UPPER LIAS—South Petherton.
INFERIOR OOLITE—Sherborne and Ham Hill.
GREAT OOLITE—Oxfordshire.
FOREST MARBLE—Oxfordshire.
CORNBRASH—Islip.
OXFORD CLAY—Oxford.
CORALLINE OOLITE—Headington and Upware.
KIMMERIDGE CLAY—Shotover.
LOWER GREENSAND—Upware.
GAULT—Cambridge.
UPPER GREENSAND—Cambridge.
CHALK—Grays and Riddlesdown.
NEWER PLIOCENE—Grays, Ilford, and Barnwell.

Your Committee desire to record their appreciation of the great favour shown to the Geologists' Association by the Universities of Oxford and Cambridge, in affording facilities for the inspection of the contents of those magnificent museums, the University Museum of Oxford, and the Woodwardian Museum of Cambridge.

Through the kindness of their respective owners and custodians, the following local and private museums have been inspected during the excursions:—

Dr. SPURREL'S Museum of Thames Valley Mammalian Remains.
Mr. JAMES PARKER'S Museum of Reptilian Remains.
Mr. EARWAKER'S Collection of Jurassic and Cretaceous Fossils.
The Rev. E. BOWER'S Collection of Mesozoic Fossils.
Professor BUCKMAN'S Collection of Jurassic Fossils.
Mr. T. C. MAGGS' and Mr. MONK'S Collections of Yeovil Fossils.
Sir ANTONIO BRADY'S Collection of Thames Valley Mammalian Remains.
The Museum of the Warwickshire Natural History and Archæological Society.
The Rev. P. B. BRODIE'S Collection of Insect Remains.

Your Committee have also to acknowledge, with great pleasure, the hospitality which has been abundantly offered to the members of the Geologists' Association who have taken part in the excursions.

The Rev. T. G. Bonney, of Cambridge, Professor Buckman, the Rev. E. Bower, and Mr. Maggs, of Yeovil, Mr. James Parker, of

Oxford, Sir Antonio Brady, of Stratford, and Mr. Kirshaw, of Warwick, have each contributed greatly to the success and pleasure of the excursions during the past year, by their generous entertainment of our members.

The Library has received numerous accessions, as well by donations from individual members, as by those from metropolitan and provincial societies. Many Scientific Societies correspond and exchange publications with the Geologists' Association, and thus our library is growing annually in value and usefulness to members. There are two hundred and ten books now in the Library, and of that number more than a quarter have been issued to members during the last year, showing how greatly the Library is appreciated.

The past year has been distinguished by the commencement of the publication of Quarterly "Proceedings," and three numbers have already been issued to members. This method of publishing the papers of value read before the Association will, it is hoped, prove more satisfactory to members than that previously adopted.

The number of members of the Association has largely increased during the year, and your Committee have great satisfaction in seeing amongst our new names those of several gentlemen who are already eminent in the scientific world, and other names which are known to be those of earnest students of Geological Science.

It is also matter for congratulation, as attesting the widening influence of the Association, that gentlemen resident at long distances from London are seeking admission to our body, and joining in our excursions, which thus become a means of bringing together geologists from various parts of England, who were previously personally unknown to each other, although well known as possessing great local as well as general geological knowledge.

It has appeared to your Committee desirable that the Laws of the Association should be modified and amended, to bring them into accordance with the altered position of the Association, and the present requirements of the members. A revision of the Laws has accordingly been accomplished, and the revised code has been duly passed at a Special General Meeting of the Association.

The Financial Position of the Association is extremely satisfactory, as will be seen from an inspection of the Treasurer's Account.

Your Committee feel that they but interpret your unanimous wishes, when they tender your thanks to the Council of University College for the courteous continuance of their grant of the Library of the College for the meetings of the Association.

You will be gratified to learn that the Rev. Thomas Wiltshire, M.A., F.G.S., &c., has intimated his willingness to continue to preside over the Association during the ensuing year.

It will be apparent from the foregoing statements that the Geologists' Association has opening before it an increased sphere of usefulness, but your Committee desire the co-operation of each one of your body in their endeavours to make our Association more and more influential for the advancement and diffusion of Geological Knowledge.

The following Papers were read during the year:—

On the Geology of the Neighbourhood of Portsmouth and Ryde, by CALEB EVANS, Esq., F.G.S.

On the Range in Time of the Foraminifera, by Professor T. RUPERT JONES, F.G.S.

On the English Crags, considered in reference to the Stratigraphical Divisions indicated by their Invertebrate Fauna, by ALFRED and ROBERT BELL.

On South African Diamonds, by Professor TENNANT, F.G.S., &c.

On the Fauna of the Carboniferous Epoch, by HENRY WOODWARD, Esq., F.G.S.

On Flint, by M. HAWKINS JOHNSON, Esq., F.G.S.

On the Upper Limits of the Devonian System, by S. R. PATTISON, Esq., F.G.S.

On an Exposure of the London Clay, at Child's Hill, Hampstead, by CALEB EVANS, Esq., F.G.S.

On the Old Land Surfaces of the Globe, by Professor MORRIS, F.G.S.

On a Recent Exposure of the Glacial Drift at Finchley, by HENRY WALKER, Esq.

On the Glacial Drifts of North London, by HENRY WALKER, Esq.

On the Overlapping of several Geological Formations on the North Wales Border, by D. C. DAVIES, Esq.

Report of the Proceedings of the Geological Section of the British Association at Edinburgh, 1871, by JOHN HOPKINSON, Esq., F.G.S., F.R.M.S.

The following is a list of the Excursions of the past year:—

	Directors.
Visit to the British Museum, 18th March.	Prof. Morris, F.G.S. Henry Woodward, Esq., F.G.S., &c. William Carruthers, Esq., F.G.S., &c.
Visit to the Museum of Practical Geology, 25th March.	Prof. Morris, F.G.S. Robert Etheridge, Esq., F.G.S., &c. Prof. Tennant, F.G.S., &c.
Excursion to Cambridge and Upware, and Visit to Woodwardian Museum, 10th and 11th April.	The President. The Rev. T. G. Bonney M.A., F.G.S. Prof. Morris, F.G.S. Harry Seeley, Esq., F.G.S.

Visit to the Hunterian Museum of the Royal College of Surgeons, 18th April.	Prof. Morris, F.G.S.
Excursion to Belvedere, and visit to Dr. Spurrel's Museum, 29th April.	Prof. Morris, F.G.S.
Excursion to Oxford, and visit to the University Museum, 12th May.	Prof. Phillips, F.R.S., F.G.S. J. P. Earwaker, Esq.
Excursion to Grays, Essex, 20th May.	The President.
Excursion to the Yeovil District, 29th, 30th, 31st May, and 1st June.	Prof. Buckman, F.G.S., &c. J. Logan Lobley, Esq., F.G.S., &c.
Excursion to Ilford, and visit to Sir Antonio Brady's Museum, 17th June.	Henry Woodward, Esq., F.G.S. Sir Antonio Brady, F.G.S.
Excursion to Caterham Junction and Riddlesdown, 1st July.	J. Logan Lobley, Esq., F.G.S., &c.
Excursion to Warwickshire, and visit to the Museum of the Warwickshire Natural History and Archæological Society, 10th and 11th July.	Rev. P. B. Brodie, M.A., F.G.S. J. W. Kirshaw, Esq., F.G.S.

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THE

GEOLOGICAL MAGAZINE.

No. XCV.—MAY, 1872.

ORIGINAL ARTICLES.

I.—On some Coniferous Remains from the Lithographic Stone of Solenhofen.

By W. T. Thiselton Dyer, B.A., B.Sc., F.L.S.

(Plate V.)

(*Continued from page* 153.)

II. *Pinites Solenhofenensis*, Dyer.

In the Häberlein collection there is a slab containing the remains of a branch, of which portions are figured in Pl. V., Fig. 1. It belonged, there is little reason to doubt, to a species of *Pinus*, in which, as in the section *Larix*, the leaves were borne in fascicles on abortive lateral branches.[1] Traces of these leaves appear to exist at *a* and *b*. The specimen affords, unfortunately, no more information than this; nothing of the kind, however, appears to have been recorded from Solenhofen, and it has therefore appeared desirable to call attention to its existence.

III. *Athrotaxites*,[2] Unger.

A large proportion of the Solenhofen plant-remains belong to types which were originally described and figured by Sternberg as Algæ. Their general facies, however, I think supports their claim to be considered Coniferous, and this has been sufficiently established by the fruiting specimen figured by Unger in the "Botanische Zeitung" for 1849 (t. v. f. 1.), under the name of *Athrotaxites lycopodioides*. Schimper has given, in his "Traité de la Paléontologie Végétale," what is evidently a figure of the same specimen (t. 75, f. 21), although the appearance of the cones is somewhat differently interpreted. He has, in fact, founded upon the view which he has taken of their structure the genus *Echinostrobus* (l. c., vol. ii., p. 331). I have not had the opportunity of seeing the original specimen, but a careful comparison of the two figures quoted above seems to me

[1] The not very intelligible *Schizolepis Braunii*, Schenk (see Schimper, Pal. Vég., vol. ii., p. 248) had similarly arranged foliage.

[2] The name of the genus founded by Don was not *Arthrotaxis*, but *Athrotaxis*. He expressly explains that the name alludes "to the crowded disposition of the leaves and scales of the female spike," and that it is compounded of ἀθρόος *confertus*. (Trans. Linn. Soc., vol. xviii., p. 174.)

to point to the cones having consisted of sub-peltiform imbricated scales swollen below, with a flat acute apex above, and not, as Schimper supposes, a spiniform appendix from their back. Now this is exactly the structure which is possessed by *Athrotaxis cupressoides*, Don,[1] and it appears to me, therefore, that we are quite justified in retaining Unger's original determination. *Athrotaxites lycopodioides* is the only one of the several species, possibly congeneric, from the Solenhofen Oolite of which the fructification is known; but it seems for the present the most convenient provisional course to retain them all as species of *Athrotaxites*. Their general facies is sufficiently congruous, although it must be admitted that this is a negative qualification, since their foliage would equally well suit some Cupressineous genera.

After an examination of the large series of specimens in the Häberlein collection, I venture to propose the following revision of the species.[2]

1. *A. princeps*, Ung., Pal. ii., p. 253, tt. 31, 32.
   Echinostrobus Sternbergii, Schimp., Tr. d. Pal. Vég. ii., p. 333, t. 75 ff. 22, 23.
   Caulerpites princeps, Sternb., Fl. d. Vorw. ii., t. 5, f. 2.
   C. laxus, Sternb., l.c., t. 5, f. 1.
   C. sertularia, Sternb., l.c., t. 6, f. 2.

   This is probably the commonest form; it is well characterized by the pinnate arrangement of the lateral branchlets, and the abbreviated and crowded ultimate ramification (Pl. V., Fig. 2).

2. *A. Frischmanni*, Ung., Pal. iv., p. 41, t. 8, ff. 4, 5, 9.
   Echinostrobus Frischmanni, Schimp., l.c., p. 333.
   Caulerpites colubrinus, Sternb., l.c., t. 4, f. 4.
   C. elegans, Sternb., l.c., t. 3, f. 3.

   In the arrangement of the leaves, this species is probably hardly different from *A. princeps*. The less crowded ramification and more elongated branchlets produce, however, a marked distinction in habit (Pl. V., Fig. 3). Nevertheless, a still more decided difference of precisely the same kind exists between *Biota orientalis* and what is held to be a seminal variety of it, *B. pendula*. It cannot indeed be too strongly remembered, in dealing with fossil plant-remains, that there is no definite correlation between the character of a plant's foliage and the structure of its fruit and flowers. The educated eye of a botanist will often from mere tact derive assistance from the *facies* of vegetative organs, but he knows, nevertheless, that the closest resemblance in the characters of leaf and stem may conceal widely different affinities. On the other hand, where the structural affinities of the reproductive organs are clear, he has no hesitation in disregarding the most marked distinctions in mere habit or foliar form.

3. *A. lycopodioides*, Ung., Bot. Zeit., 1849, p. 345, t. v., ff. 1, 2. (Pl. V., Fig. 4).
   A. Baliostichus, Ung., Pal. iv., p. 40, t. 8, ff. 1, 2, 3.
   Baliostichus ornatus, Sternb., l.c., t. 25, f. 3.
   Echinostrobus Sternbergii,[3] Schimp., l.c., Explication des Planches, p. 27, t. 75, ff. 21, 24.
   E. lycopodioides, Schimp., l.c., ii., p. 333.

   This is characterized by the minute imbricated leaves in numerous rows. In *Baliostichus* these appear to be merely represented by the marks of their attachment to the stem. A peculiarity in this species is a tendency to forked

[1] See Hooker's Icones Plantarum, t. 559.

[2] After removing the Solenhofen plants from the genus *Echinostrobus*, the only remaining species are *E. robustus*, Sap., and *E. expansus* (*Thuites expansus*, Sternb.). Of the last Schimper appears not to have seen cones; had he done so, he could not, I think, have retained it in its present position.

[3] *E. lycopodioides* was the name no doubt intended to be used here. The same specimen could hardly be referred to two distinct names in the same enumeration.

branching. Don, in his original description of the genus *Athrotaxis* (l.c., p. 174), remarked that the recent species frequently present "a dichotomous appearance, which arises from the non-development of one of the lateral branches, the normal arrangement being a primary axis with two opposite lateral branches." If this view is accepted, it is immediately applicable to Figs. 3 and 4 of Pl. V.

4. *A. longirameus*, Dyer.

Caulerpites longirameus, Sternb., l.c., p. 103, t. 29, f. 3.

I attach this name to specimens in which the stems are stouter than in the other species, and at the same time elongated, and very sparingly branched; the vertical series of leaves are also more numerous (Pl. V., Fig. 5).

5. *A. ? laxus*, Dyer.

Caulerpites laxus, Sternb. l. c. p. 22, t. 5, f. 1.

C. ocreatus, Sternb. l. c. p. 103, t. 29, f. 2.

I am strongly impressed with the belief that the two names just cited belong to the same plant, the one being founded on the lower, the other on the upper portion of a branch. The affinities of the species are, however, to the last degree doubtful; it appears to have had scale-like leaves, finally becoming distant and indurated (Pl. V., Fig. 6).

C. ocreatus, Sternb., it has been suggested to me, may be correlated with the branchlet figured by Mr. Carruthers from the Oxford Clay of Chippenham, Wiltshire (Geol. Mag., Vol. VI., Pl. II., Fig. 11). That, however, appears to exhibit a two-fifths phyllotaxis, and may therefore belong to an Angiosperm.

IV. *Condylites*, Dyer, gen. nov., Pl. V., Fig. 7.

In the Häberlein collection there is a specimen (Pl. V., Fig. 7) apparently unique, which, though offering far from satisfactory material for description, appears to me too important to be allowed to remain unnoticed. Its general facies leaves little doubt in my mind that it is truly Coniferous, but I am unable to assign it a place in any known genus. I propose, therefore, to establish it as a new generic type, under the name *Condylites*, which I have had suggested to me as indicating the singular elbow-like insertion of the branches.

According to my interpretation the leaves were scale-like and closely imbricate. It seems by no means improbable that the remains of foliage referred above to *Athrotaxites longirameus* may belong to this plant; they have at any rate considerable resemblance.

The cones, although apparently lateral, were really terminal, the continuation of the stem being a lateral branch. The scales were, as far as I can judge, imbricate (Pl. V., Fig. 7*a*), and not "valvate," as in such genera as *Callitris*. On the whole, I conclude its place to be amongst *Cupressineæ*, and its nearest affinities with *Thuya*. In that genus, however, the female cones are terminal on *lateral* branches, and the scales of the cone are decussately opposite; I doubt if this was the case in *Condylites*. In default of a more complete analysis of the cone structure, the following must serve as a diagnosis of the genus.

Condylites, Dyer, gen. nov., Ramuli lignescentes foliis minutis persistentibus squamatim tecti. Strobili terminales, quasi in cymam uniparam alternatim dispositi, subglobosi depressi; squamæ admodum paucæ, imbricatæ, rotundatæ, coriaceæ (an sublignosæ).

C. squamatus, Dyer, species unica.

* * * *

Adopting Parlatore's division of the *Coniferæ* into the two tribes *Abietineæ* and *Taxineæ*, we find that all the species from Solenhofen enumerated above belong to the former group. It is observable also that if the affinities of the fossil plants placed under *Athrotaxites* and *Condylites* have been properly ascertained, each of the subtribes of the *Abietineæ* is provided with at least one representative in the Solenhofen Oolitic Flora,—*Athrotaxis* belonging to the *Taxodieæ*, and *Condylites* most probably to the *Cupressineæ*. It is further also interesting to notice that in that case, besides an undoubted species of *Eutacta*, we have from Solenhofen an additional link in *Athrotaxites* to connect existing Australian living forms with those of the Oolitic age.

II.—Notes on the Relations of the Rhætic Beds to the Lower Lias and Keuper Formations in Somersetshire.[1]

By Horace B. Woodward, F.G.S., and J. H. Blake, Assoc. Inst. C.E., F.G.S., Of the Geological Survey of England and Wales.

IT would at first sight seem superfluous that anything more should be written upon the relations of the Rhætic Beds in England, for during the past twelve years they have received so much attention—the principal sections have been described, and the beds have been well and successfully searched for fossils. But whilst there has been no lack of petrological and palæontological evidence,—and we ought to be very thankful to railway companies in the western counties for opening up so many fine sections,—still it is somewhat astonishing to remark, there has been and there still appears to be a considerable diversity of opinion on the subject of the relations of the beds. Some authorities have placed them with the Lias, others with the Trias; some regard them as quite an independent formation, others as passage-beds belonging as much to the one as to the other.

That the last-mentioned notion is gaining ground, we have no doubt, and Prof. Ramsay's[2] recent paper on the subject will have done much to impress this opinion.

Stratigraphical evidence ought to be sufficient to determine the question, for when this is clear, palæontology must be subordinate. Upon this point, in reference to Somersetshire, we propose to offer a few remarks, particularly as certain statements of unconformability have been brought forward, which have an important bearing on the geological rank of the Rhætic beds among the formations.

To Mr. Charles Moore[3] we owe the first clear exposition of the Rhætic beds of Somersetshire, and the illustration of their organic remains. His classification of the beds has been generally accepted; and although a lower junction with the Keuper, so as to include the whole of the Grey marls with the Rhætic series, has been adopted by the Geological Survey,[4] this is a point of no great importance,

[1] This paper is published by permission of the Director-General of the Geological Survey.

[2] Quart. Journ. Geol. Soc., vol. xxvii. p. 189.

[3] Quart. Journ. Geol. Soc., vol. xvii., p. 483.

[4] H. W. Bristow, Report Brit. Assoc. for 1864; Geol. Mag., Vol. I., p 236. See also W. B. Dawkins, Quart. Journ. Geol. Soc., vol. xx., p. 396; Geol. Mag., Vol. I., p. 257; Vol. II., p. 481.

and merely confirms the opinion that there is no abrupt line between the two series of deposits.

The junction of the Lower Lias with the Rhætic beds is in many parts of Somersetshire well marked, and this is more particularly the case on the north than on the south of the Mendip Hills. Taking, as Mr. Moore does, the White Lias with its top "Sun-bed" or "Jew-stone,[1] as the upper limit of the Rhætic beds, the change from its even-bedded and clean-looking white limestones to the irregular blue and brown earthy and argillaceous limestones and clays of the Lower Lias, may usually be detected at a glance in most quarries, or even, as Mr. Moore remarks, from the window of a railway-carriage, when passing through a cutting where these rocks are exposed.

This is the case generally all over the area occupied by these rocks between the Avon and the Mendip Hills.[2]

To the south of this range in many places the junction is not so apparent, the lithological change is more gradual, so that it is often difficult to say where the junction is, even when the beds are traced out carefully on the ground.

Thus, in the railway-cutting west of Shepton Mallet Station, the junction with the Lias is clear and well marked; but further west, only five miles distant, at Milton Lane, near Wells, also near Wedmore, and along the Polden Hills, the junction is not so distinct. The limestones at the base of the Lower Lias become paler in colour, and approach in character some beds of the White Lias, while the clays are replaced by soft white marls, and higher up by what have been aptly termed slaty marls. There are occasionally several beds in the Lower Lias which closely resemble the "Jew-stone." Further, the most abundant fossils at the junction, *Ostrea Liassica* and *Modiola minima*, are common to the Lias and Rhætic beds.

Towards the Blackdown Hills the White Lias has a meagre development, whilst at Watchet it is still more attenuated.

The stratification of the Lias and Rhætic beds is always conformable, and although the change of sediment is more marked in some places than in others, we have no reason on stratigraphical or lithological grounds to separate the two, any more than we should separate the black paper-shales from the White Lias. Indeed, the change is no greater than that which is repeated in the Lias in the alternations of clay and limestone which compose its mass.

We will now turn our attention to the junction of the Rhætic with the Keuper Marls. Here, likewise, there is a perfect conformability and a clear passage from one into the other; everywhere the evidence is unequivocal. Commencing with the Keuper beds, we find, as has frequently been pointed out, that in ascending the series, the

[1] "Sun-bed" is the term applied by quarry-men in the neighbourhoods of Bath and Radstock to the top bed of the White Lias. It is a hard cream-coloured or bluish limestone with a conchoidal fracture. The term "Jew-stone" is applied to the same bed near Wedmore and along the Polden Hills.

[2] We must refrain from details, as these will appear in a Geological Survey Memoir on the district, now in course of preparation.

red marls become more variegated, and frequently alternate with green and grey marls now in rapid succession, then in alternate masses, until we lose the red entirely, and enter upon the hard and soft green, grey, white, and buff-coloured marls which constitute the base of the Rhætic series. Sometimes one or two bands of red marl occur several feet up in these latter marls. It is therefore impossible to fix a boundary, save that of colour, which is liable to so much variation, that the same horizon cannot be accurately determined in different sections.

Evidences of unconformability between these beds have, however, been put forward, and these we must proceed to notice. Mr. Moore[1] alludes to the frequent unconformability of the Lower Lias, Rhætic, and New Red Marl, due to "the absence of some of their members." Whilst at Queen's Camel, where the section is complete, he observes that there is "a clear passage upwards, without any break, from the upper beds of the Keuper, through the Rhætic and White Lias series into the Lower Lias," yet to the North of the Mendips this is not the case. In this area he finds a total absence of the zones of *Ammonites planorbis* and of *A. angulatus;* but the latter occurs in the zone of *A. Bucklandi,* which thus rests directly on the White Lias. Although he has "no special faith in precise Ammonite or other zones of life,"[2] Mr. Moore regards the absence of the zones as evidence of unconformability; and this feature extends as far as Bath.[3] Mr. Moore alludes also to the paucity of Saurian remains in this area.

As we have mentioned, the junction of the Lias with the Rhætic beds on this side of the Mendips is more distinctive than it is to the south, there being no difficulty in determining it; but the stratification of the beds is always conformable, and there is no evidence of any marked lapse of time between the deposition of the two series. Certainly the *Planorbis*-beds were never deposited in this area and subsequently removed; the thinning out of the Lower Lias appears to be due to a suspension of sediment or slowness of deposition. Mr. Moore accounts for the attenuation of many of the Secondary beds in this area on the ground that the Mendip Hills formed a barrier against the incursion of sedimentary matter to the north. If this be true, they may have formed a barrier to check the migration of the *Ammonites planorbis.*

At all events, we do not see that this feature in any way affects the general conformability of the Rhætic and Lower Lias, or indeed of any of the other Secondary strata, some of which show a striking attenuation.

Neither can we admit that "*the absence of some of their members,*" whether lithological or palæontological, necessarily constitutes a proof of unconformability. It would be most unreasonable to suppose that the same operations and conditions were in force forming

[1] Quart. Journ. Geol. Soc., vol. xxiii., p. 459, etc.

[2] Quart. Journ. Geol. Soc., vol. xvii., p. 487; vol. xxiii., p. 471.

[3] *Ammonites planorbis* occurs at Keynsham, and we have noticed it in the cutting near Bitton Station on the Midland Railway. We have also obtained it in the cherty beds of the Lias at Harptree Hill.

sediment of a like nature, synchronously, over the extensive area where these formations are known to occur. So, likewise, with respect to their entombed organic remains, "we may expect that species found in some places may not be discovered in others, since we can scarcely anticipate that it would be otherwise, or that all the creatures existing even upon a moderately-sized area in the waters beneath which this mass of calcareous matter and mud was accumulated would be found in one locality."[1]

Mr. Moore[2] points out what he considers to be a possible unconformability between the Red Marl and the Rhætic beds in the sections at Watchet, Aust, and Penarth, because there the Rhætic beds are seen to lie almost immediately upon gypseous marls, whereas at Hatch, near Taunton, a different series of marls intervenes.

To this we need only reply that the occurrence of gypsum is very local, being sometimes present and sometimes absent in the same series of marls only a short distance apart. Thus to the west of Watchet, gypsum is very abundant, whereas to the east it is absent, although the general lithological character of the beds is the same. Gypsum also occurs at different horizons, as may be seen in the instructive coast section to the west of Watchet, where it occurs in the Red Marls of the Keuper, and likewise in the thin-bedded grey, black and buff-coloured marls of the Rhætic series, commencing about 30 feet above the junction of the latter with the Red Marls, and extending to within a few feet of the black *Avicula contorta* shales. It is equally abundant in both series of marls, occurring in nodules, nodular bands and fibrous veins, of various thickness, the latter intersecting the beds in every conceivable direction. Thus the formation of the gypsum is evidently of posterior date to the deposition of the marls, and instead of tending to prove unconformability between the Rhætic beds and New Red Marl, rather points to the intimate relations of the two series of conformable beds.[3]

Professor Ramsay[4] regards the Lias and Rhætic beds as conformable, but he mentions "symptoms of erosion" which have been observed between them at Penarth and Curry Rivell. The Sun-bed at Curry Rivell presents an irregular surface, and the same feature is present on the surfaces of other beds of the White Lias below. Regarding the Rhætic beds as "formed in shallow water under brackish semi-estuarine conditions," he remarks that estuarine or tidal sea-currents would have been sufficient to produce these phenomena when the Lias-sea first came across a slowly sinking area.

We have never met with any evidences of erosion due to exposure at the time to atmospheric influences. Evidences of shallow water and of pauses in deposition occur at all horizons in the Rhætic series, though they are not to be frequently observed. They consist

[1] De la Beche's Geological Report on Cornwall, Devon and West Somerset, p. 232.

[2] Quart. Journ. Geol. Soc., vol. xxiii., p. 468.

[3] I am inclined to think that the veins were formed after the beds were consolidated, the striæ being always at right angles to the walls of the same, whereas the nodules may have been formed by segregation or otherwise when the beds were unconsolidated, and perhaps shortly after their deposition.—J.H.B.

[4] Quart. Journ. Geol. Soc., vol. xxvii., p. 197.

of sun-cracks, pseudomorphous crystals of rock-salt, ripple-marks, sands and conglomerates.

Some writers[1] have pointed to the occurrence of perforations by boring molluscs in the top beds of the White Lias. During the past four years we have looked in vain for any such evidence. There are certainly curious hollows sometimes apparent in these beds, but none that we have observed could be referred with certainty to the action of Pholas or any other marine mollusc. Nor have any traces (so far as we are aware) of any marine boring mollusc been detected in these beds. Pholas is not even recorded from the Lias of this country.[2]

There seem to be two kinds of perforations. The one in the form of hollows in the stone, evidently produced after the consolidation of the rock. But we have noticed that wherever these occurred it was either where the beds were denuded of the Lower Lias, and thus exposed at the surface, or it was on the faces of joints. They are clearly due to atmospheric influences; possibly snails may have done something, but sufficient evidence of the boring power of these animals has not yet been brought forward. Some few holes, as Mr. Moore tells us, are due to the weathering out of Corals.

The other kind of perforation is that which occurs in the upper beds of the White Lias at Curry Rivell, near Taunton. Messrs. Bristow and Etheridge have obtained some very fine specimens showing tubular perforations extending two or three, and sometimes nearly six inches, into the stone. They are deposited in the Museum at Jermyn Street. The nature of these perforations indicates that they were formed contemporaneously with the sediment now consolidated, that is to say, that they were the burrows of some marine animal in the soft calcareous mud of the Rhætic period. Mr. Etheridge is inclined to refer them to an Annelid, or possibly to Lithodomus. It is not, however, probable (the stratigraphical evidence so strongly forbidding such a notion) that the upper beds of the White Lias were consolidated previously to the deposition of the Lower Lias; so that we could not expect to find evidences of perforations by any lithodomous mollusca of that period.

Sometimes the upper surface of the Sun-bed or Jew-stone, where it is exposed, presents a striated appearance, being crossed in all directions by fine grooves. It is difficult to account for this; but the notion originally suggested by the Rev. J. Sutcliffe,[3] that such striations on limestones were originally sun-cracks, seems a plausible theory. Subsequent pluvial action has done much to modify and enlarge them.

The Cotham Marble, which occurs at the base of the White Lias, and frequently the Sun-bed, have an irregular corrugated surface, which, as Conybeare[4] remarks, "sometimes represent the interlacings

[1] Amongst whom Moore, Quart. Journ. Geol. Soc., vol. xxiii., p. 496.

[2] Tate, Census of the Marine Invertebrate Fauna of the Lias, Geol. Mag., Vol. VIII., p. 4.

[3] A short Introduction to the Study of Geology, 1817, p. 21.

[4] Geology of England and Wales, p. 264.

of ivy." These appearances have been referred to by some as eroded surfaces. The structure of the stone, however, forbids such a notion, as thin layers may often be split off, which correspond to the irregular surface. Indeed, as Edward Owen,[1] the man who first described the Landscape Marble, pointed out more than a century ago, "the rough coat itself is composed of a great many thin coats laid over one another." It is the same irregularity, as it seems to us, which on a larger scale is seen so often in the limestones of the Lower Lias—a structure probably induced during the drying and consolidation of the deposits. The Cotham Marble, as is well known, occurs in isolated masses.

Professor Ramsay has pointed out the formation of the New Red Marl in an inland salt lake, and how the same general geographical features ushered in the Rhætic series; subsequently a gradual sinking of the area caused a partial influx of the sea over shallow bottoms. Marine forms thus migrated from a true Rhætic ocean, but during a long period shallow water under brackish semi-estuarine conditions prevailed, until the conclusion of Rhætic times, when the purely marine conditions of the Lower Lias period predominated.[2]

Thus we have a clear explanation of the fauna of these times, and can understand the migration into the area of Ammonites and other Cephalopoda, which in this country are the chief palæontological features which distinguish the Lias from the Rhætic beds.

We have not yet sufficient material for tracing out the probable boundaries of the Rhætic formation in the British area. In several places we find evidences of old coast margins,[3] and it remains to be seen whether possibly some of the Dolomitic Conglomerates and breccias of the Mendips, instead of all being regarded as beach deposits of the Keuper period, may not be regarded as of newer date.[4] De la Beche [5] remarks that "in some localities we scarcely know where to draw the line between the Dolomitic and Lias Conglomerates," which is accounted for by a continuation of "the same general physical causes for the production, accumulation, and consolidation of the gravel and fragments."

That so distinctive a name as Rhætic be given to these beds, and that they should be mapped separately, are points which are not seriously affected by our opinions as to their relations. They may be conveniently regarded as a stage connecting the Keuper formation with the Lias, and belonging as much to the one as to the other, —a stage in the history of the area under consideration which, commencing with the conglomerates, sandstones, and marls of the Keuper

[1] Observations on the Earths, Rocks, Stones, and Minerals about Bristol, etc., 1754, p. 163.

[2] Quart. Journ. Geol. Soc., vol. xxvii., p. 189. See also Memoir of Edward Forbes, by Wilson and Geikie, p. 418.

[3] At Nempnet, near Chew Stoke, I mapped, in 1867, some beds of Conglomerate as of Rhætic age.—H. B.W.

[4] The idea was first suggested to us in 1868 by Mr. Gibbs, late of the Geological Survey. It is also held by Mr. Moore, in his paper on the Geology of the Mendips, Proc. Somerset Arch. and Nat. Hist. Soc., vol. xv.

[5] Mem. Geol. Survey, vol. i., p. 272.

period, continued uninterruptedly into the Liassic and Oolitic stages. The Rhætic beds may therefore be regarded as equal in importance, geologically speaking, as any of the three divisions of the Lias or of the subdivisions of the Oolites. Economically, the mapping of these beds has the same value. They seldom occupy a large superficial area at their outcrop, as they are generally exposed on the slopes of Liassic escarpments, the New Red Marl appearing along the base, and its junction with the grey marls of the Rhætic series being often plainly seen at long distances. Their agricultural character is, therefore, more or less peculiar, and whilst the Red Marl is dug for manure, the White Lias is largely used in the construction of walls, and for road-mending; whilst the Lower Lias limestones are used for building and paving purposes, and are extensively burnt for lime.

As Mr. Etheridge has remarked,[1] if our views were based upon purely stratigraphical and petrological conditions, we should assign no independent position to the Rhætic beds, for they indicate a gradual change of physical conditions, necessarily marked by palæontological differences.

Finding, as we do at Queen Camel, in the sections near Watchet and other places in Somersetshire, such a complete passage between the Keuper and Liassic beds, with about 100 feet for the thickness of the intervening Rhætic series, we cannot say that in them we have a complete representation of all the beds of the great Rhætic formation of South Europe. In different areas the changes would not be contemporaneous, and even in the British area we should not be surprised to find that Rhætic conditions prevailed longer in one part than another.

In conclusion, we may mention that our object has been to discuss certain local features connected with the relations of the Rhætic beds, to show that we have no evidences of any unconformability in Somersetshire, and that such observations agree with the opinion which is rapidly gaining ground, that in them we have true passage-beds between the Lower Lias and Keuper formations, graduating more or less imperceptibly from the one into the other, the lowest members being more nearly allied lithologically and palæontologically to the Keuper, the upper members being similarly allied to the Lower Lias. Thus the Rhætic beds form a *connecting link* between the "Oolitic or Jurassic," and the "New Red Sandstone or Triassic" systems.[2]

[1] Proc. Cotteswold Nat. Field Club for 1864, vol. iii., p. 220.

[2] I would urge that a uniform system be adopted in our classification of strata. By placing the Rhætic beds as a separate period, we give the beds an importance which they certainly do not possess in this country; and therefore it seems better to include them in the Trias, mainly as a matter of convenience, as such an arrangement is now adopted by the highest authorities. *Vide* Jukes and Geikie, Manual of Geology. Account of Rhætic Beds, p. 613, by H. W. Bristow. Hull, Memoir on the Triassic and Permian Rocks of the Midland Counties of England. Phillips, Geology of Oxford and the Valley of the Thames, p. 101.—H. B. W.

III.—Notes on the Geology of Prince Edward Island, in the Gulf of St. Lawrence.

By J. W. Dawson, LL.D., F.R.S., Principal of McGill's College, Montreal.

THE writer had the opportunity last summer, with Dr. B. J. Harrington as assistant, to re-examine the rock formations of Prince Edward Island, of which a notice was given in the second edition of his "Acadian Geology." The report of our reconnaissance, which has been published by the local government, with a map, sections, and figures of fossils, may be referred to for details; but I propose in this paper to notice a few points of general scientific interest not dwelt on in the report.

Prince Edward Island is crescentic in form, about 100 miles in length, and lies in the almost semi-circular bend formed by the southern shore of the gulf of St. Lawrence. It is one of the most populous and best cultivated portions of British America. Its surface, though low, is undulating and agreeably diversified with farm and forest, and beautiful arms of the sea. Its climate is comparatively mild and insular, and its soil of excellent quality; while the marly beds of decomposing oyster and mussel shells in its bays and creeks afford an apparently inexhaustible means of restoring the productiveness of the fields.

The prevailing formation is the Trias, which here, as in Nova Scotia and in Connecticut, is represented principally by bright red sandstone, sometimes mottled with white, and associated with occasional beds of grey and white sandstone. Subordinate to these sandstones are beds of red and mottled clay, of reddish concretionary and conglomerate limestone, sometimes dolomitic, and of reddish conglomerate with quartz pebbles and arenaceous cement. These beds undulate in low synclinals and anticlinals, having in general a north-east and south-west direction, and rise in some places to an elevation of 400 feet above the sea. They are probably about 500 feet in vertical thickness. The lower half of this thickness, which contains the limestone beds and also certain hard beds of conglomerate and concretionary calcareous sandstone, may be regarded as an equivalent of the Bunter sandstone; while the upper portion, consisting principally of soft red sandstone, with some beds of fine-grained conglomerate, may be regarded as corresponding to the Keuper.

In the little isolated spot named Hog or George Island, there occurs a limited mass of doleritic trap. It includes both the compact and vesicular variety, and the latter has its cavities filled with a white mineral, which Dr. Harrington ascertained to be Saponite. This trap, which was first noticed by Dr. Gesner in 1847, appears to be contemporaneous with the red sandstone, and is similar to that which occurs on a much larger scale in connexion with the Triassic sandstones of Nova Scotia and Connecticut.

The Triassic beds have afforded no distinct marine fossils, but in the lower beds some vegetable remains occur. One of these is a small cycadean stem presented to me by Mr. J. W. Taylor, F.G.S., and which I have described and figured as *Cycadoidea* (*Mantellia*) *Abequidensis*, the specific name being taken from the old Micmac appellation of Prince Edward Island—*Abequid*, "Lying in the water," Fragments were also found of coniferous wood belonging to a species of *Dadoxylon* (*Araucaroxylon*) allied to *D. Keuperianum* of Europe, and which I have named *D. Edvardianum*. The specimens of this tree, which were found by Dr. Harrington, had all been bored with minute cylindrical holes, similar to those now made by the crustacean *Limnoria terebrans*. These holes being filled with clear calcite, while the wood is of a reddish colour, give the trunks and branches the aspect at first sight of endogenous stems. Branches having the aspect of *Knorria* were also found, and obscure *Sternbergiæ* piths; and in some of the beds there are numerous cylindrical bodies of various sizes, perhaps stems of fucoids. These Triassic beds have also afforded the jaw of the remarkable reptile described by Dr. Leidy under the name of *Bathygnathus borealis*, and which seems to have been a Dinosaur, probably allied to those which have left the gigantic trifid tracks on the red sandstone of Connecticut. We were not so fortunate as to find any additional remains of this creature.

The views which I stated in 1848, in the Journal of the Geological Society, as to the chemical nature and origin of the Triassic red sandstones of Nova Scotia, appear to be perfectly applicable to those of Prince Edward Island.[1] They appear to have been deposited in a shallow sea area, not improbably coincident with the Southern Bay of the Gulf of St. Lawrence, limited to the north by the Magdalen Islands and the banks in their vicinity, which represent an old Lower Carboniferous outcrop. Their materials were derived from the waste of red sandstones and marls of the Carboniferous, and have been thrown down with sufficient rapidity to prevent the coating of red oxide of iron from being removed by abrasion or by the chemical action of organic matter. The dolomitic character of some of the coarse limestones may either indicate the occurrence of occasional isolated basins and depositions of magnesia from sea-water,[2] or may have been connected with the outburst of igneous matter rich in magnesia, like the dolerite of Hog Island, near to which place the beds richest in magnesia were observed.

On the West coast of Prince Edward Island, and at Gallas Point and Governor's Island in Hillsborough Bay, the beds of the Upper Coal-formation appear rising in low anticlinals from beneath the Trias. As on the neighbouring coast of Nova Scotia, these beds scarcely differ in mineral character from those of the Trias, except in the somewhat darker colour of the red sandstones, and the greater frequency of shales, grey sandstones, and concretionary limestones. Their fossils indicate the highest zones of the Carboniferous next to the Permian, corresponding to the "Annularia" and "Fern" zones of Geinitz in Germany. The dips of these Carboniferous beds are not appreciably greater than those of the Trias resting on them, so that we have here the interesting fact of the conformable super-

[1] See also Acadian Geology, pp. 24 and 623.
[2] As explained by Dr. Sterry Hunt.

position of the Carboniferous on the Trias without the intervention of the Permian. This is the more remarkable, as in Nova Scotia the Triassic beds usually rest unconformably upon disturbed Carboniferous rocks. The anticlinals of the coal-fields of Nova Scotia and New Brunswick, however, flatten out very much towards the coast, and retaining the same attitude under Northumberland Strait, they present very gentle inclinations under Prince Edward Island. Hence only the higher beds of the Newer Coal-formation are seen, and the Permian age having no representative, fossils alone indicate the distinction of the Carboniferous and Triassic formations. The beds seen in Prince Edward Island thus represent only a small portion of the upper part of the Newer Coal-formation. They contain no beds of coal, though trunks of carbonized trees appear in the sandstones at Gallas Point; and judging from the arrangement observed in Nova Scotia, the upper coal-seams may be at a depth of from 500 to 2000 feet. These coal-beds nevertheless underlie the whole of Prince Edward Island, and may some day be reached.

The most abundant fossil in the Newer Coal-formation of Prince Edward Island is a coniferous tree of the genus *Dadoxylon* (*Araucaroxylon*), and which I identify with my species *D. materiarium*, which is extremely abundant in the upper sandstones of the Coal-formation of Nova Scotia. These trees are mostly silicified, but specimens also occur mineralized by carbonate of lime and per-oxide of iron, and in a carbonized condition. The cracks formed by decay in the silicified specimens are often filled with a red variety of sulphate of barium. In Nova Scotia a *Walchia* or *Araucarites* (*A. gracilis*) probably represents the foliage of this tree, and the same species occurs with it in Prince Edward Island, and also a second species of the same genus. These Walchias may be regarded as Permian in aspect; but it must be remembered that there is every reason to believe that the genus *Walchia* includes leafy branches of *Dadoxylon*: and the circumstance that in Europe the trunks are more characteristic of the upper coal-formation and the branches of the Permian is merely an accident of preservation.

The other fossils found in these beds are the following. Those marked with asterisks occur also in the upper coal-formation of Nova Scotia:—

**Pecopteris arborescens*, Schlot.
**P. rigida*, Dawson.
**P. oreopteroides ?* Brongt.
P. (allied to *P. Goepperti*, Brongt.)
**Alethopteris nervosa*, Brongt.
A. massilionis, Lesqux.
**Neuropteris rarinervis*, Bunbury.
**Cordaites simplex*, Dawson.
**Calamites Suckovii*, Brongt.
**C. Sistii*, Brongt.
C. gigas, Brongt.
C. arenaceus ? Jaeger.
Trigonocarpum, sp.

This may be regarded as on the whole an assemblage characteristic of the newest beds of the Upper Coal-formation. Several of the species are in Europe common to the Carboniferous and Permian; but none of them are exclusively Permian. The beds containing such fossils constitute the newest members of the Carboniferous both in Nova Scotia and in Europe.

The superficial deposits of Prince Edward Island consist of

Boulder-clay, stratified sand and gravel, and loose travelled boulders. The prevalent Post-pliocene deposit is a Boulder-clay, or in some places boulder-loam, composed of red sand and clay derived from the waste of the red sandstone. This is filled with boulders of red sandstone derived from the harder beds. They are more or less rounded, often glaciated, with striæ in the direction of their longer axis, and sometimes polished in a remarkable manner, when the softness and coarse character of the rock are considered. This polishing must have been effected by rubbing with the sand and loam in which they are embedded. These boulders are not usually large, though some were seen as much as five feet in length. The boulders in this deposit are almost universally of the native rock, and must have been produced by the grinding of ice on the outcrops of the harder beds. In the eastern and middle portion of the Island only these native rocks were seen in the clay, with the exception of pebbles of quartzite which may have been derived from the Triassic conglomerates. At Campbellton, in the western part of the Island, I observed a bed of Boulder-clay filled with boulders of metamorphic rocks similar to those of the mainland of New Brunswick.

Striæ were seen only in one place on the North-eastern coast and at another on the South-western. In the former case their direction was nearly S.W. and N.E. In the latter it was S. 70° E.

No marine remains were observed in the Boulder-clay; but at Campbellton, above the Boulder-clay already mentioned, there is a limited area occupied with beds of stratified sand and gravel, at an elevation of about fifty feet above the sea, and in one of the beds there are shells of *Tellina Grœnlandica.*

On the surface of the country, more especially in the western part of the island, there are numerous travelled boulders, sometimes of considerable size. As these do not appear *in situ* in the Boulder-clay, they may be supposed to belong to a second or newer boulder-drift similar to that which we shall find to be connected with the Saxicava sand in Canada. These boulders being of rocks foreign to Prince Edward Island, the question of their source becomes an interesting one. With reference to this, it may be stated in general terms, that the majority are Granite, Syenite, Diorite, Felsite, Porphyry, Quartzite and coarse slates, all identical in mineral character with those which occur in the metamorphic districts of Nova Scotia and New Brunswick, at distances of from 50 to 200 miles to the South and South-west; though some of them may have been derived from Cape Breton on the East. It is further to be observed that these boulders are most abundant and the evidences of denudation of the Trias greatest in that part of the Island which is opposite the deep break between the hills of Nova Scotia and New Brunswick, occupied by the Bay of Fundy, Chiegnecto Bay and the low country extending thence to Northumberland Strait, an evidence that this boulder-drift was connected with currents of water passing up this depression from the South or South-west.

Besides these boulders, however, there are others of a different character; such as Gneiss, Hornblende schist, Anorthosite and Labradorite rock, which must have been derived from the Laurentian rocks of Labrador and Canada, distant 250 miles or more to the Northward. These Laurentian rocks are chiefly found on the North side of the island, as if at the time of their arrival the island formed a shoal, at the North side of which the ice carrying the boulders grounded and melted away. With reference to these boulders, it is to be observed that a depression of four or five hundred feet would open a clear passage for the arctic current entering the Straits of Belle Isle to the Bay of Fundy; and that heavy ice carried by this current would then ground on Prince Edward Island, or be carried across it to the Southward. If the Laurentian boulders came in this way, their source is probably 400 miles distant in the Strait of Belle Isle. On the North shore of Prince Edward Island, except where occupied by sand dunes, the beach shows great numbers of pebbles and small boulders of Laurentian rocks. These are said by the inhabitants to be cast up by the sea or pushed up by the ice in spring. Whether they are now being drifted by ice direct from the Labrador coast, or are old drift being washed up from the bottom of the gulf, which north of the island is very shallow, does not appear. They are all much rounded by the waves, differing in this respect from the majority of the boulders found inland.

The older Boulder-clay of Prince Edward Island, with native boulders, must have been produced under circumstances of powerful ice-action, in which comparatively little transport of material from a distance occurred. If we attribute this to a glacier, then as Prince Edward Island is merely a slightly raised portion of the bottom of the Gulf of St. Lawrence, this can have been no other than a gigantic mass of ice filling the whole basin of the gulf, and without any slope to give it movement except toward the centre of this great though shallow depression. On the other hand, if we attribute the Boulder-clay to floating ice, it must have been produced at a time when numerous heavy bergs were disengaged from what of Labrador was above water, and when this was too thoroughly enveloped in snow and ice to afford many travelled stones. Farther, that this Boulder-clay is a submarine and not a subaerial deposit, seems to be rendered probable by the circumstance that many of the boulders of sandstone are so soft that they crumble immediately when exposed to the weather and frost.

The travelled boulders lying on the surface of the Boulder-clay evidently belong to a later period, when the hills of Labrador and Nova Scotia were above water, though lower than at present, and were sufficiently bare to furnish large supplies of stones to coast ice carried by the tidal currents sweeping up the coast, or by the Arctic current from the North, and deposited on the surface of Prince Edward Island, then a shallow sand-bank. The sands with sea-shells probably belonged to this period, or perhaps to the later part of it, when the land was gradually rising. Prince Edward Island thus appears to have received boulders from both sides of the gulf of St. Lawrence during the later Post-pliocene period; but the greater number from the South side, perhaps because nearer to it. It thus furnishes a remarkable illustration of the transport of travelled stones at this period in different directions; and in the comparative absence of travelled stones in the lower Boulder-clay, it furnishes a similar illustration of the homogeneous and untravelled character of that deposit, in circumstances where the theory of floating ice serves to account for it, at least as well as that of land-ice, and in my judgment greatly better.

The modern deposits observed were extensive beds of Peat, Oyster-beds, or "mussel mud," Dunes or sand-hills, Shore Ridges or "shooting-dykes."

Of the Peat deposits examined, the most important was that of "Black bank" in Cascumpec Bay, which is reported by Dr. Harrington as having an area of nearly three millions of square yards, and an average depth of fifteen feet. It presents a steep front to the bay, the waters of which are now gradually removing it; and a little below low-water mark, it has a layer of roots of trees which indicate a forest surface now under the level of the sea. Similar evidences of modern subsidence were observed in other places. At Gallas Point, for example, there is a layer of stumps five feet below high-water mark.

The common American oyster, *Ostrea Virginiana* and *var. Borealis,* occurs abundantly on the coast, and large accumulations of its shells with those of the mussel, *Mytilus edulis,* have been formed in some of the bays and river estuaries. I was informed by Mr. W. H. Pope, who has given much attention to this subject, that some of these beds are fifteen feet or more in thickness. They consist of dead shells, and in many places no living shells occur even at the surface, the animals having been killed by the gradual approach of the beds to the surface of the water, exposing them to the action of the frost and ice and to invasion of sandy sediment. These beds of dead oyster and mussel shells, with the mud filling the interstices, constitute one of the most valuable deposits on the Island. Under the name of "Mussel Mud," this material is taken up in great quantity by ingenious dredging machines, worked from rafts in summer or from the ice in winter, and is applied as a manure to the soil with the most excellent effects. It supplies lime and organic matter, besides small quantities of phosphates and alkalies.

The shells in these old beds are all of the long narrow form (*O. Virginiana*), and Mr. Pope informs me the round form (*O. borealis*) occurs at the surface in many places where the long narrow form is found only a few inches below. It also appears that the modern oysters procured in the upper parts of the rivers and on muddy bottom tend to the long form, while those in more salt water and on hard bottom are round.

"Dunes," or mounds of drifted sand, are extensively developed along the outer or north-west shore, where they extend in long lines across the bays and parallel to the coast. In all they extend in length about 45 miles, and are sometimes more than 40 feet high. Though usually held together by the roots of coarse grasses, they are liable to frequent changes, which are much promoted by the cropping of the grass by the cattle or by any artificial or accidental breaking of the surface. At St. Peter's I saw an old entrance used in the early French times quite filled up with the blown sand; and I was told that a hill 40 feet high had been removed within a few years, and had disclosed the remains of an old blacksmith's forge under its base. The sand in these hills is derived from the waste of the red sandstones; and, when left dry by the tide, is blown up by the wind. The attrition to which it has been subjected has removed the coating of red oxide of iron from the siliceous grains of sand, so that, though derived from red rocks, these sands are nearly white. Where the sand-hills run along the coast, a long narrow channel often occurs between them and the shore, and they often block up streams, forming lagoons, in which deposits very different from those of the open gulf are produced.

Mr. Pope kindly pointed out to us on a creek near Grand River, and on Ives Creek, the mounds known locally as "shooting-dykes," in allusion to their use by sportsmen as a shelter in duck-shooting. These are somewhat regular banks or dykes of soil fringing the creeks, and having almost the appearance of artificial earth-works, which they have indeed been supposed to be. Some of them are six feet in height and ten feet wide at base. I believe them to be of the same nature with the Lake Ridges of Nova Scotia described in my Acadian Geology,[1] and that they have been produced by the expansion or driftage of the ice, which forms in the creeks in winter. They constitute a sort of "Moraine" deposit, which, on a larger scale and in a more hilly country, might readily be mistaken for the work of glaciers. Those that we saw were entirely composed of soil intermixed with vegetable matter. Some of them showed evidence of formation by successive increments of material. Their steepest sides were next the land, and they were highest opposite the most exposed and widest portions of the creeks.

IV.—The Succession of the Crags.

By Alfred Bell.

ALL geologists, especially those who, like myself, are interested in the study of the Upper Tertiaries, are indebted to Mr. Prestwich for the valuable memoir upon "The Structure of the Crag-beds of Suffolk and Norfolk."[2] As the views propounded therein are somewhat novel, I purpose examining some of the points brought forward in their support.

The presence of Diestien fossils in the Suffolk Crag, and the cause of their being there, appears to me to be susceptible of a simpler explanation than has been given. Mr. Lankester considers them to be the remains of an older formation, which was broken up by the Crag Sea. This will not account for all the phenomena noticed, and I shall venture upon a few words concerning the older Pliocene deposits. Between the Falunian (Upper Miocene) and

[1] Page 35. [2] Quarterly Journal Geol. Soc. London, 1870 and 1871.

Plaisancien and Astien (Lower? Pliocene) stages, the progress of geological science demands the intercalation of other groups. Prof. Sequenza has described an extensive deposit in Sicily and S. Italy, intervening between these two stages, termed by him "Zancleano." With this stage may be correlated the following deposits, *i.e.*,—the Marne Vaticano near Rome, the Lower Val d'Arno near Florence, Montpellier in France, on both banks of the Tagus near Lisbon, in Andalusia and Catalonia (?) in Spain, at Salles in the Gironde, the Bolderberg Hill in Belgium, and probably some of the Holstein and North German beds. These beds appear to be the oldest Pliocene deposits of Western Europe.

Succeeding these, occur the horizons to which appertains the sub-Appenines of Italy, Sicily, Dauphiny, and Provence (both marine and freshwater), the blue marly clays of Malaga,[1] the so-called Crag of Normandy, the Sables noirs of Belgium and Guelderland in Holland, and probably the ferruginous ironsand extending at intervals for nearly 200 miles from the hills near Dorking, in Surrey, through N.E. France and Belgium to Holland.

Favoured by Sir Charles Lyell, I am able to supply a geological want, *i.e.* the list of species collected by him in the aforesaid Norman Crags. Comparison will show that they belong to an older stage than any of the English Crags.

Astarte Omalii
**Cytherea*, sp.
Kellia ambigua ?
**Leda pella*
Lucina borealis
Mactra subtruncata
Nucula nucleus
,, *lævigata ?*
Ostrea edulis
Pecten opercularis
* ,, *Philippii*
Solen
Thracia pubescens
**Venericardia (Jouannetti ?)*
Calyptrea chinensis
**Crepidula gibbosa*
Cerithium tricinctum
**Cerithium*, sp.
**Eulima*
Murex exculpta
Natica proxima
,, *hemiclausa*
,, *helicina*
* ,, 2 sp.
Nassa prismatica
,, *reticosa*
,, *granatina*
* ,, *gibbosula*
**Patella*, sp.
?*Rissoa*
Trochus bullatus
,, *ziziphynus*
**Turbo exarata*
Voluta Lamberti

In addition to these, M. Hebert gives *Axinus flexuosus, Astarte mutabilis, Corbula gibba, Mactra arcuata,* **Crepidula unguiformis,* **Chemnitzia gracilis* (Broc.), *Natica millepunctata,* **Turritella vermicularis,* and *Nassa propinqua.* These are all that are known from the Norman Crags. 15 out of the 44 (thus marked *) being absent from the English Crags.

The ironsands are generally unfossiliferous; this, I presume, is owing more to their physical composition than to original poverty of life, as from the box-stones and the Lenham sands I possess a list of 86 forms referable to 67 genera, indicating a richer fauna than is generally supposed.

Halloy has provided for these sands, by supposing them rather

[1] See the interesting series, collected by Mr. H. Woodward at the Tejares, Malaga, in 1860, preserved in the British Museum.

to have been ejected from a submarine cleft opening between Calais and Diest, than to be an ordinary marine operation. He, however, especially notices the tendency which the glauconitic grains have to form nodular concretions.

The richly fossiliferous black sands of Belgium and Holland rest upon the Lower Miocenes, at but a slight elevation (if any) above the sea-level; the ironsands, on the contrary, are never less than 180 feet above it.

Now, assuming that the ironsands represent the in-shore and shallower waters of the Diestien sea, the black sands would also represent the deeper. It is then obvious that when the elevation of the Wealden dome exposed the upper sands to the action of the currents flowing from Normandy to the North Sea, the easily decomposed sandstone would be destroyed, whilst the harder nodules would be carried over the sea-bottom.[1] When in process of time, the lower black sands were brought into the same range of action, they would be likewise denuded, and their Molluscan contents removed, and carried with the nodules into the later Red Crag sea. I can find no easier hypothesis to account for the presence of so many Black sand shells in the Red Crag and *not* in the Coralline.[2]

Which of the 50 or 60 Cetacea are proper to the black sands, is uncertain, and the same with the Mammalia; but from present evidence, they are quite as likely to be of the age of the deposits they occur in as not.

Before passing to Mr. Prestwich's memoir, I may remark, that as the Belgian "Sables gris" contain shells, which in England do not occur in the Coralline Crag but only in the Red Crag, the presumption is, that they are either immediately posterior in date to the Coralline Crag, or belong to its latest development. Amongst these are *Melampus pyramidalis*, *Fusus elegans*, *F. antiquus*, *Littorina subaperta*, *Cardium Parkinsoni*, *Tellina lata*, etc. M. Nyst informed me, when looking over his collection at Brussels, that he then considered the Sables Jaunâtres to be of the same age as the Sables gris. The fauna is almost the same, and is exactly that of the English Middle (or Red) Crag. The Upper Crag (of A. and R. Bell) does not obtain in Belgium, but appears near Dordrecht, in Holland, as there we meet *Nucula Cobboldiæ*, *Leda limatula*, and others.

The sum of Mr. Prestwich's argument seems to be as follows. That the whole series of English Crags are divisible into two—the Coralline and the Red Crags; the latter being again divided into two divisions, the lower comprehending all the beds hitherto denominated Red and Norwich Crag, the upper the Chillesford sands and clays covering the whole, Coralline Crag included.[3]

[1] That is the Coralline Crag sea.

[2] Six or eight *Pleurotomas*, including, *P. turricula*, Broc., *P. intorta*, a large *Mitra*, one or two Volutes, a *Cassis*, *Ranella anglica*, *Murex exculpta*, *Nassa conglobata* (?), *Tellina Benedenii*, etc., perhaps twenty in all. Also *Solenastrea Prestwichii*, and a tolerably common *Flabellum* (? n.sp.).

[3] The division into zones of the Coralline Crag is of much value, but from my own investigation, I think some of the zones, considered as separate, really are concurrent with each other. Thus at the Gomer Pit, I found the zone *f* included the fossils of zone *d*, the larger shells immediately underlying the zone containing the smaller.

This statement is supported by the "absence of any definite order of succession in the various beds of the lower" division of the Red Crag, and the absence of any "distinction in the organic remains from the base of the Red Crag to the top of the lower division" (embracing the Norwich Crag), except that north of the Iken ridge the fauna assumes a more littoral character, becoming much poorer after passing Butley.

These points I now propose to examine. Omitting as of little value any reference to the indefinite stratification of the beds, I must remark that I have already stated in the pages of this MAGAZINE[1] my reasons for dividing the Red Crags into two horizons (each possessing a deep and shallow water fauna), with a difference between them of 190 species of shells alone. The lists were the tabulated results in separate columns of collections made in the pits of Walton, Waldringfield, Foxhall, and Sutton, for the older; and at pit G of Mr. Prestwich's plan, at Ramsholt, Bawdsey, Butley Farm, Butley Mill, and in the Chillesford Stackyard for the Newer Red Crags.

As an admirable plan is given by Mr. Prestwich, I shall confine myself at present to the question, how far it bears out Mr. Prestwich's deductions?

Pits D and G open at opposite sides of the Coralline Crag Hill (vide plan), the Red Crag being represented as completely surrounding it, but in excavating along a trench on the east side of the zigzag field north of the cottage, we found that the Coralline Crag came to the surface under the top soil, the Red Crag lying by the side as if it had formed in a hollow of the older deposit, both afterwards having been planed off to one level. This Coralline Crag extends across the field and separates the Red Crag of the two pits; thus showing that the Red Crag does not surround the Coralline Crag Hill as in the plan. In preference to making the Coralline Crag Hill a little islet in the Red Crag Sea, I would suggest that at this date it was a continuous reef trending westward, on opposite sides of which the older and newer Red Crags were formed.

The shells obtained from the trench were *Ostrea cochlear*, *Pecten princeps*, *P. maximus*, *Cyprina Islandica*, *Panopea Faujasii*, *Trochus ziziphynus*, *Buccinopsis Dalei*, *Fissurella costaria*, *Balanus concavus*, and others as at Ramsholt.

Unfortunately I cannot offer so large a list of the fossils of pit D as I should like, but as in the mass the fossils are those of the adjacent pits near the Sutton Farm and Shottisham, I have grouped them together. The following species of the pit D and the immediate neighbourhood do not occur in pit G or any beds of the same horizon that I have collated with it: *Pecten Westendorpianus*, *Mytilus phaseolinus*, *Limopsis aurita*, *Leda minuta*, *Chama gryphöides*, *Cardium decorticatum*, ? *Kellia suborbicularis*, *Erycina Geoffroyi*, *Astarte triangularis*, *A. crebriliratra*, *Isocardia cor*, *Cardita orbicularis*, *Venus imbricata*, *Lucinopsis Lajonkairii*, *Lutraria elliptica*, *Donax politus*, *Tellina Benedenii*, *Panopea Faujasii*, *Pandora rostrata*, *Pholas cylindrica*, *Fusus alveolatus*, *F. consociale*, *F. elegans*, *Buccinum*

[1] The English Crags. By A. and R. Bell. GEOL. MAG. 1871, Vol. VIII., p. 256.

glaciale, Nassa consociata, N. elegans, N. prismatica, Desmoulea conglobata, Pleur. carinata, P. decussata, etc., *Natica cirriformis, N. varians, Scalaria fimbriosa, Adeorbis subcarinatus, Emarginula crassa, Brocchia partim-sinuosa, Scaphander lignarius*; that is to say, 37 species of one pit unrepresented in another pit close at hand. If the peculiar contents of pit G are examined, we find amongst them *Rhynchonella psittacea, Buccinum ciliatum, Pleurotoma exarata, Fusus Largillierti, F. Turtonis, Natica nitida, N. occlusa, N. Grœnlandica,* etc. Many other forms in this pit are very rarely represented, to what they are in the other places, and *vice versâ;* thus, while in the majority of the old pits (D. etc.) the sinistral form of *F. antiquus* is the predominant one, in the newer horizon, it is the dextral forms that most abound. There are many other differences in size and arrangement of the fossils, that I need not stop to go into. I think I have shown sufficient reason against the argument that the two faunas were deposited in the same sea. Of the peculiar shells of the older beds, Waldringfield alone would supply 40, and Walton 20 more, in addition to the above.

The juxtaposition of the Red Crag in pits D and G to the Coralline Crag Cliff, is available upon another point. If the Red Crag fauna is so largely supplemented by Coralline Crag fossils, how comes it that here the Coralline Crag fauna is so sparely represented. Where are the *Limœ,* small *Astartes, Verticordiœ, Poromyœ, Panopeœ* (*P. fragilis*), *Tellina donacina,* or the many *Chemnitziœ, Eulimœ, Odostomiœ, Pyramidellœ, Triforis, Cerithia,* and *Cerithiopses, Cœca, Dischides,* all the *Opisthobranchs,* and many other genera? I cannot find them in the ordinary way a collector works, *i.e.* by careful sifting of the material in which they ought to be found, and I confess that except the wear and tear of the sea in rolling the broken-up Crag had, as I suspect it has, *totally* destroyed its contents, I am at a loss to explain their absence. It is certain that they are not there.

Concerning the depth of the Red Crag Sea, I shall merely say that if the Pholades (in their Crypts), *Mytilus,* and *Purpura,* indicate a littoral zone, so also do the Brachiopoda (*vide* Mr. Jeffreys), the *Fusi, F. Turtoni, F. Largillierti, F. Norvegicus, Cassidaria bicatenata, Buccinopsis,* and other genera indicate deep water. A submergence of the former would allow the fauna of the latter to accumulate. I see no other way out of the dilemma.[1]

Contrary to the views of Mr. Prestwich, I find the "characteristic land and freshwater features of the Norwich Crag" set in *South* of the Iken ridge. Of 23 species of this class, Mr. Prestwich himself quotes 10 from Butley and Waldringfield. As the exertions of the Norwich and Suffolk geologists (whose names are legion) have brought up the Mollusca of this Trans-Iken Sea to 170 species, and the Cis-Iken area of the same age (our Upper Crag, op. cit. p. 261) only musters 220, I do not think it can be considered as much "poorer."[2]

[1] A similar condition obtains in the Post-Pliocene clays of Belfast. Mr. Stewart informs me that the base is characterized by *Pholas crispata overlaid* by a zone of *Thracia convexa.*

[2] Is not "*Bulimus*" noted as occurring at Bulchamp an error?

The difference in age will account for the absence of the typical forms (*i.e.* Southern and Coralline) of the older areas from this. The abundance of *Littorina* and *Turritella* alone marking the Trans-Iken area, and that only in certain places.

In as few words as possible, I have endeavoured to show that a great difference does obtain in the Red Crag marine fauna, marking two distinct geological horizons. I have confined myself to the Mollusca, although in every class of animal life the same differences prevail more or less. It is further in proof of my statement, that the only terrestrial mollusca of the lowest Red Crag are of an extinct species, those of the newer division living in our own land at the present day.

The Chillesford Sands and Clays.—If the "unproductive sands" which cover the whole of the Coralline Red and Norwich Crags are of Chillesford age, I am in error in considering the totally unfossiliferous sands capping the Shelly Crag at Butley (see GEOL. MAG., 1871, Vol. VIII., p. 450) as of different age; but as the whole of these sands, whether in Suffolk or Norfolk, are unfossiliferous, I must still be content to retain them as older, or rather that when the denudation of the Crag area commenced (so well seen at Butley), the "unproductive sands" were thrown down, as we always find that below the Chillesford shell-bearing sands, whether at Chillesford, Sudbourn Church Walk, Aldeby, Norwich, or elsewhere, these sands invariably underlie them, sharply making a distinct horizon and a different condition of things.

I cannot assign the Bawdsey Cliff fossils listed by Mr. Prestwich to this stage. In mode of deposition, in character, and in species, the shells are the same as in those of the Upper Crag area (of A. and R. Bell).

The uncertainty as to the value of the "argillaceous" zone, and the disagreement as to its range among geologists, renders the age of the Forest bed a still open question; but I am happy to be able to supplement Mr. Prestwich's list of shells from Runton by the following species, either obtained by Mr. Reeve or myself: *Sphærium rivicola* (Kessingland), *Pisidium amnicum* var. *sulcatum*, *P. fontinale*, *P. Henslowiana*, *Unio littoralis*, *Valvata antiqua*, *Planorbis corneus*, *P. nautileus*, *P. nitidus*, *Limnea pereger*, *Ancylus fluviatilis*, *Physa fontinalis*, *Succinea putris*, *Helix hispida*, *H. arbustorum*, *Carychium minimum*, *Zua lubrica*, *Limax agrestis*.

The name *Unio margaritifera* in Mr. Prestwich's list is added through an error. The specimen referred to, which is in the Norwich Museum, is an *Anodon*.

There are two exceptions I must take to the lists of Mollusca, which bear upon the per-centage question. I notice that many extinct forms are referred to existing species, or else they are termed *varieties*. How this can be, I am at a loss to understand, when the so-called variety lived, as far as we know, in advance of the typical form. Taking an extreme case, *Tellina Benedenii*, which first appears in the Black Belgian Sands, is termed a variety of *Tellina lata*, which first appears in the "Sables gris," a deposit posterior to the Coralline Crag.

As I am made jointly responsible with Mr. Jeffreys for the additional species recorded in the lists, it may be proper here to state that Mr. Jeffreys is the authority for the following species: Coralline Crag, *Cardium Norvegicum, Lima elliptica, Lutraria oblonga, Modiola discors, Psammobia costulata, Solecurtus antiquatus, Thracia distorta Aclis,* 3 sp., *Emarginula rosea, Murex aciculatus, Odostomia insculpta, Rissoa proxima.* Red Crag, *Cardium nodosum, Panopea plicata, Pholadomya papyracea, Dentalium abyssorum, Actæon exilis? Conopleura Maravigne? F. despectus, Menestho albula, Rissoa striata, Trochus Grœnlandicus.*

How far variety extends is a matter of opinion, but *A. exilis* is described by Mr. Jeffreys as having three whorls and *A. Etheridgii* by myself as with 5-6. *Conop. crassa* is not the same as *C. Maravignæ,* if sculpture is any criterion, and with respect to *Pleurotoma attenuata,* var. *tenuicosta,* it must be a very elastic variety indeed, if it embraces all the distinctive marks of the species Mr. Jeffreys assigns to it. When I requested Mr. Jeffreys' opinion upon the shells in question, I suggested that one of them was *P. attenuata*; on comparison with his figured specimen he thought not, and proposed the name *notata,* which I afterwards adopted for one of my species.

V.—On Changes of Climate during the Glacial Epoch.

By James Geikie, F.R.S.E.,

District Surveyor of the Geological Survey of Scotland.

(*Sixth Paper.*)

(*Continued from the April Number, p.* 170.)

It has already been sufficiently insisted that no warm or genial climate has intervened since the close of the Glacial epoch. The climate of Britain is milder now than at any other period subsequent to the re-elevation of our country after the last great submergence; our winters have been gradually growing less intense; Britain has slowly passed from an Arctic to a temperate condition of things. Mr. Dawkins accounts for the absence of the mammal-bearing drifts in Scotland and the upland districts of England by supposing that in post-glacial times all these regions were covered with snow and ice. This, however, is a rather exaggerated picture of post-glacial Britain. It is quite true that after the emergence of our country from the last great subsidence, a few local glaciers continued to linger on among our mountain valleys. But the Lowlands of Scotland were most assuredly never again covered with glacier-ice. In post-glacial times the low country of Scotland was just as free from ice as the low grounds of England. And since the hippopotamus and his congeners do not occur in the post-glacial drifts of Scotland, this must be owing to some very different cause than that suggested by Mr. Dawkins. If the hippopotamus, the elephant, the rhinoceros, the hyæna, the lion, the *Machairodus,* and others, really lived in England during the post-glacial period, they cannot have failed to occupy Scotland at the same time. Yet if they did so, where are their remains? and where in Scotland do we meet with deposits like those of the Thames and other English valleys? The Scottish post-glacial deposits have yielded relics only of Arctic and northern species, and these, as we trace the drift-beds upwards into recent accumulations, gradually give place to the present fauna. The condition of Scotland after the re-elevation of the land in post-glacial times became suited to the wants of reindeer and their northern associates, but certainly not to those of the hippopotamus and his congeners. Nor can it be for one moment supposed that while Arctic conditions obtained in Scotland, a mild and genial climate characterized England.

I might therefore rest the case simply upon this question of post-glacial climate,—the presence of hippopotamus betokens a mild and genial winter: no such genial climate has intervened since the close of the Glacial epoch; therefore the hippopotamus cannot possibly have lived in Britain in post-glacial times. But the purely geological evidence seems not only not against but positively in favour of this conclusion. The mere intermingling of Arctic and southern forms in the same river-deposit cannot be considered a difficulty. No one who has studied the formation of river sands and gravels will fail to see how fossils entombed at widely-separated intervals may come to occupy the same level. Rivers are constantly cutting down through their own deposits, and again filling up the excavations they make. In this way gravel and sand are banked against similar beds which may belong to a much greater antiquity; and the line of junction it is often impossible to determine—the one deposit seeming to shade into the other.

Nor need the absence of the mammalia from the interglacial beds of the north-west and east of England surprise us. For, in the first place, these beds are of marine formation, and every one knows how rarely remains of land animals occur in such deposits; and, in the second place, it is unlikely that the marine interglacial beds referred to were laid down at a time when the large mammalia inhabited Britain. When the cold of any particular Arctic period had reached its climax, and a thick sheet of ice overflowed Scotland and a great part of England, it is quite impossible that any portion of Britain could have been tenanted by the large mammalia. Even the tichorhine rhinoceros and the mammoth must have gone south. Again, when the cold had passed away, and the climate was getting temperate, our country could only have become populated by means of a land communication with the continent. It may, therefore, be inferred that during the warm interglacial period or periods, when the hippopotamus and its southern associates visited these latitudes, our country formed part of the continent, and consequently that the marine deposits then thrown down are even yet covered by the waters of the ocean.[1] The records of past time are preserved chiefly

[1] This conclusion receives strong support from the views advocated by Adhemar, Croll, and others, concerning the effect likely to be produced upon the level of the ocean in our hemisphere by the presence of a great ice-cap at the antipodes. During a cold period in the southern hemisphere there would be a tendency to an increase of land-surface here—an increase, however, which we have at present no certain means of estimating.

in the mud and sand of old sea-bottoms—land-surfaces have not often been covered up and handed down. During the deposition of the English glacial and interglacial drifts, Britain may have been several times united to the continent and again separated, without any record of such continental conditions having been preserved in the marine drifts that border her maritime districts. For I hardly suppose any geologist will seriously hold that the succession of the drift deposits either in the east or north-west of England is continuous—that there are no gaps between the beds, but that from the Forest-bed up to the latest postglacial deposit we have an unbroken series, telling one connected tale. In Scotland the erosion during glacial and interglacial periods was excessive; and the superficial deposits of England must also have been subjected to considerable denudation throughout the whole cycle, from glacier ice, from pluvial and river action, and from the sea.

It may be said that the older river-gravels occupy valleys or depressions which have been eroded through glacial drifts. But in coming to this conclusion is it not just possible that geologists may sometimes have been influenced by preconceived opinions with regard to the age of the mammaliferous drifts? It does not follow, because a bed of Boulder-clay appears to be cut off by the slopes of a valley, that the valley in question has been hollowed out since the deposition of the Boulder-clay. To say the least, it seems just as feasible a supposition that the valley, with some portion of its sand and gravel deposits, may have existed before the accumulation of the Boulder-clay, and subsequently become partially filled up with that bed, which, when the stream once more began to flow, would be denuded and re-arranged or even swept away. During this process the older alluvia or valley gravels would also be greatly denuded; yet it is not at all improbable, but even highly likely, that some portion would be spared. If this were the case, it would be next to impossible to separate these out from the newer gravels which overlaid them, unless indeed the latter should be found to contain stones which could only have been derived from the Boulder-clay. As an example of what is meant, reference may be made to the highly interesting section of the Biddenham deposits given by Mr. Wyatt.[1] The section is as follows:

"Thin course of earth.
Dark-red clay discolourations by infiltration.
Subangular gravel, mostly worn, and chiefly composed of flints, small fragments of iron shale of the greensand, and a few portions of the older rocks.
Sand.
Vein of sandy clay.
Sand.
Thin layer of black, apparently woody, matter. *Helix.*
Fine gravel.
Sandy clay layer. *Succinea.*
Sand, occasional angular pieces of flint.
Many shells, principally of the *Succinea*, *Planorbis*, and *Cyclas.*
Coarse gravel, boulders of red sandstone, flints, older rocks—some very large. ochreous.

[1] See *The Geologist*, 1861, p. 243; and Mr. Prestwich's paper in Quart. Journ. Geol. Soc., vol. xvii., p. 364.

Layer of ochreous clay. Shells, *Cyclas.*
Smaller gravel. *Implements.* Bones and teeth of *Elephas*, Deer, *Bos*, etc.
Limestone rock."

It may be admitted that the boulders of older rocks occurring in the "coarse gravel" near the base, and in the "subangular gravel" near the top of this section, have been derived from the Boulder-clay of the adjoining higher grounds; yet it by no means follows that the underlying bed of "smaller gravel" has had a similar origin. For all that can be shown to the contrary, it may belong to a much more remote antiquity than the Boulder-clay in question, and may date back to interglacial or even to preglacial times.

It is quite certain, however, that mammal-bearing gravels have been found to rest upon Boulder-clay. Mr. Prestwich put this beyond all doubt by showing that at Hoxne certain freshwater beds which have yielded flint implements and mammalian remains were superposed on Boulder-clay. Nevertheless this does not prove that these fluviatile deposits are of post-glacial age. To make this certain we should require to show that the Boulder-clay in question belongs to the close of the Glacial epoch; for what I hold is, that the deposition of Boulder-clay and other glacial drifts both preceded and succeeded the formation of some at least of the older valley-gravels. The consideration of this point raises the wide question of the age of the English valleys. Are those valleys postglacial, interglacial, or preglacial? In a former paper[1] I took the liberty of saying that the sequence of the glacial deposits as developed in Scotland being so comparatively simple, we might with advantage view this sequence as typical, and that thus we might obtain a key to solve the difficulties which beset the student of the glacial accumulations in England. We may now advance a step further in this correlation of geological phenomena. Some years ago I attempted to give a brief account[2] of the kind of denudation to which Scotland had been subjected since glacial times, and I showed, what indeed was familiar to most geologists, that its chief features were impressed upon the country in ages long anterior to the advent of the Glacial epoch. Here and there we find the streams flowing in deep ravines which they have scooped out for themselves since the deposition of the glacial drifts; but although they may not thus always flow exactly in their preglacial and interglacial channels, yet nevertheless they make their way to the sea along the same great lines of drainage which marked the country before the first approach of glacial cold. In short, the present river-cuts are postglacial and recent, but all the main valleys in which these river-cuts are made existed in preglacial times. There is nothing to show that it is otherwise with the valleys of England. "One thing is certain," Professor Ramsay says, "that before the Glacial epoch the greater contours of the country were much the same as they are now."[3] Such being the case, there is nothing unreasonable in supposing that

[1] See Geol. Mag. for March.
[2] See Trans. Glas. Geol. Soc., vol. iii., p. 54.
[3] Physical Geog. and Geol. of Great Britain, p. 142.

preglacial and interglacial deposits may exist in the English valleys, just as they occur in those of Scotland. In the paper referred to above, it was further pointed out that the last excessive denudation of the Scottish glacial and interglacial drifts was effected mainly during the growth of the sand and gravel (kames) series. "During that period waves and currents often ploughed out the till in the narrow straits and seas to a large extent, while in the fiords and other sheltered regions this deposit escaped the same degree of erosion, and the configuration then given to it has not been obliterated by the atmospheric forces, although these have been so long employed in its reduction." I do not under-estimate the erosion by frosts, rain, and rivers since the re-elevation of the land from the last great submergence. It would be strange that any one familiar with the aspect of our hills and valleys should dream of doing so; the later denudation has undoubtedly been enormous: yet I feel convinced that upon the whole the glacial and interglacial deposits of Scotland still retain much of the appearance they presented after the final retreat of the sea. If we are to believe that the preglacial and interglacial river-deposits of England have all been swept away, and that the valley-gravels belong exclusively to postglacial times, then we must also believe that the marine denudation during the last great submergence and the subsequent subaerial erosion have been much more excessive in England than in Scotland, and that far greater physical changes have been effected in the former than in the latter country since the re-elevation of the land.

Since the deposition of the older valley-gravels of England, considerable derangement of the drainage-system has taken place. Mr. Prestwich remarks, "One feature of these deposits is, that although closely related to the present configuration of the surface, yet they are always more or less independent of it. They are often near present lines of drainage, yet could not, as a whole, possibly have been formed under their operation."[1] In this respect they closely resemble the Scottish interglacial beds, to which, indeed, the entire description just quoted most aptly applies. It has been already shown that the partial or complete filling up of the preglacial and interglacial river-cuts with drift deposits has often so modified the contour of the ground as to compel the streams in postglacial and recent times to hollow out for themselves new cuts in drift deposits and the solid rocks. In Scotland, glacial deposits are so well marked that there is no possibility of their being mistaken for anything else; they tell us in language that cannot be misconstrued, that the gravels, sands, silts, etc., lying in old water-courses beyond the reach of the present streams are preglacial and interglacial,—we cannot by any ingenuity explain away the superimposed Till. But the glacial deposits of many parts of England are by no means so well defined. The further we recede from the mountains of that country, the glacial drifts become less and less distinguishable. To such an extent is this the case, that geologists are sometimes at their wits' end to say whether the large stones occasionally met with in the

[1] Phil. Trans. 1860.

valley-gravels have been carried into their present position by floating ice, or whether they may not have been derived from the denudation of a Boulder-clay. In the former case the stones would give evidence of cold conditions; in the latter they would afford no proof of anything in particular, save river-erosion. This we may be sure of, that the river-drainage of England must have been frequently interrupted during the cold periods of the Glacial epoch, by deposits from land-ice, from icebergs, and from the drifting and sifting action of marine currents. When a cold period had passed, and the rivers once more began to find their way down the slopes of the land to the sea, it is more than likely that they would not be able always to get into their former channels. In some cases these would be filled up, or partially so, with Till or Boulder-clay, or marine gravel and sand. And such obstructions of the drainage and consequent deflection of the streams might be, or rather must have been, repeated again and again. Thus, on the supposition that some at least of the older valley-gravels are interglacial and perhaps preglacial, their abnormal position in reference to the present lines of drainage would receive a simple explanation,—an explanation which it seems to me is not antagonistic, but supplementary to the leading ideas entertained by Mr. Prestwich.

The well-known fact, that the mammalian remains and flint implements of the older valley-gravels are most frequently found at or near the bottom of such deposits, appears to favour these general conclusions. Surely, if the gravels where wholly of postglacial age, we might expect to meet with flint implements and bones as plentifully in the upper as in the lower portions of the beds. But that such is not the case agrees well with the supposition that the mammaliferous beds are mere patches of old interglacial river-deposits, covered up by later accumulations, some of which are undoubtedly fluviatile, while others may be marine or estuarine.

Again, it is noteworthy that while the older river-gravels in the south of England are usually well developed, as in the basin of the Thames, those of the valleys further north occur for the most part in mere patches. This circumstance appears inexplicable on the supposition that the valley-gravels are wholly postglacial; but if the theory here supported have any truth in it, the apparent anomaly is only what might have been expected. For, in the first place, the valleys of the Thames and those of the south of England, being far removed from the centres of glaciation, have not been subjected to the same degree of erosion as the valleys to the north; and, in the second place, the ground south of the Thames does not appear to have been submerged during the accumulation of the kames and esker drift, and so has escaped the great tear and wear which then overtook the superficial accumulations in Scotland, and also as I believe in the drowned districts of England.

It is thus then that I would explain the sorely wasted aspect and often anomalous position of the valley-gravels of England and the almost entire absence of mammal-bearing drifts in Scotland and Ireland. In those countries and the hilly districts of England, the interglacial deposits must have been ploughed out again and again whenever a glacial period supervened, and even during interglacial periods subaerial denudation would carry on the work of destruction; in short, the deposits of each period would be made up to a large extent of pre-existing drifts. But as we recede from the uplands and approach the low country, we get upon ground where glacial action would be less intense, and where, consequently, interglacial deposits would stand a better chance of preservation.

But it may still be objected that if the older river-gravels are really of interglacial age, we ought to find them in some places at least covered by glacial deposits. Now I will not stop to ask how often this may have been the case without the glacial character of the overlying deposits having been recognized. Hitherto, the postglacial age of the valley-gravels has been by many assumed, not proved. Yet it is not too much to say that the mere absence of an overlying cap of glacial clay or sand, or silt or gravel, is not sufficient evidence of the postglacial age of a deposit. Such an overlying bed may have been removed by denudation, or it may never have existed. But we do find in the valley-gravels themselves evidence of cold climatal conditions. I need only refer to the well-known occurrence of the travelled stones and boulders which Mr. Prestwich thinks may point to transport by means of floating-ice; and the confused and tumultuous appearance which many of the older river-deposits present may also, he believes, be accounted for by the grounding of heavy ice-rafts. This explanation at once commends itself by its simplicity; but whether the transport of the boulders and the confused bedding of the gravels have in all cases been effected by river-ice is at least doubtful. Granting, however, that they have been, and that the deposits in which these phenomena occur are of postglacial age, it is quite clear that the conditions of climate which Mr. Prestwich's theory demands could not have been suited to the wants of the hippopotamus. Nor could we reasonably expect to find a mammalian fauna at once so varied and abundant as that of our river-gravels and cave-deposits, living in England at a time when the winters were so intensely severe. Is it not more reasonable, then, to conclude, that the southern forms had already left Britain before the climate had so cooled down as to permit the presence of large ice-rafts on our rivers; in other words, that the travelled boulders and confused bedding point either to the approach or the disappearance of a cold or glacial period?

But still stronger evidence in this direction is furnished us by the "Trail" so lucidly described by the Rev. O. Fisher. If this peculiar deposit be not due to the action of land-ice, as Mr. Fisher contends, to what other cause can we ascribe it? The chief objection which it appears to me can be urged against the explanation given is only our own preconceived idea that valley-gravels as a rule must belong to a later date than the Glacial epoch. But freshwater deposits of interglacial age occur in Scotland, Switzerland, and America,[1] and

[1] In a former paper (Geol. Mag., Vol IX., p. 64) I referred to the "Hardpan" of North America as being in all probability the equivalent of our Till. Since then

should Mr. Fisher's theory of the origin of "Trail" be ultimately accepted, as I can hardly doubt it will, then we shall be compelled to admit the interglacial age of some English gravels also. For if it be certain that no warm period has intervened since the close of the Glacial epoch, it is equally certain that within the same time no climate severe enough to nourish land-ice beyond the limits of our mountain valleys has supervened in Britain.

Some twenty years ago Mr. Godwin-Austen pointed out in one of his most suggestive papers,[1] that the "subaerial beds" of the English Channel area were the equivalents of the glacial deposits elsewhere, and that the broad alluvia and gravels of such rivers as the Severn, the Fab, the Dart, the Thames, etc., belonged to a period anterior in date to the great depression during which the high-level marine drifts of Wales were accumulated. In other words, he showed that these river-gravels could not be referred to post-glacial times.

There are still some points to be urged in favour of the views which I have ventured to put forward in this paper; but a consideration of these points must be deferred for the present.

VI.—On Meteorites.[2]

By David Forbes, F.R.S.

On the previous occasions upon which I have had the honour of lecturing in this hall,[3] my observations were confined to the consideration of the structure of the earth beneath our feet. Now, however, I would crave your indulgence still further, when I attempt to carry your thoughts with me to infinitely higher regions by directing your attention to the study of what may be termed the mineralogy of the heavens above us.

In responding to the invitation of your worthy Secretary, to deliver a lecture "On Meteorites," I feel myself greatly embarrassed by the conviction that all we know of these wonderful natural phenomena is so imperfect and incomplete that even those who have devoted most time to their study will find difficulty in answering such apparently simple questions as—What are Meteorites? or, Where do they come from?—questions which most of you are doubtlessly prepared to ask, in the full expectation of receiving a satisfactory reply.

Under these circumstances, therefore, all I can do is to lay before you a summary of what we at present know concerning meteorites, and the opinions of those who have specially studied them; but before commencing I would premise by explaining that the term Meteorite, as understood in this present discourse, is restricted to

I have been assured by a friend well acquainted with the superficial deposits of Scotland and North America, that my inference is quite correct, and that the *hardpan* answers in every respect to *till*.

[1] Quart. Journ. Geol. Soc., vol. vii., p. 118.

[2] Being a lecture delivered at St. George's Hall, Langham Place, London, 7th April, 1872.

[3] See Geol. Mag., 1870, Vol. VII., p. 314. Lecture on Volcanos, delivered June 19th, 1870.

such meteors which, from their having at various times fallen down from the atmosphere on to our earth, have afforded us the means of examining their physical and chemical nature, and to which the names of Meteorites or Aerolites, *i.e.* meteoric or atmospheric stones, have been specially applied. That such bodies in their descent present the appearance of balls of fire or luminous meteors is well known; but as yet we are not certain that all luminous or igneous meteors are true meteorites in this sense, notwithstanding that recent researches indicate that falling stars, meteors, meteorites, and even comets, are all bodies differing only in size, but otherwise similar, if not identical, in composition. The descent of falling stars, fiery globes or thunderbolts, as they are commonly called from the attendant noise, has, without doubt, often attracted man's attention even in the most ancient or prehistoric times; for we find amongst the traditions of all nations, descriptions of glowing meteors rushing down from the heavens, to the dire consternation of the inhabitants of the earth, who long imagined them to be harbingers of war, pestilence, famine, or other dreadful calamities in store for them, and retained the belief that some such catastrophe would end in the entire destruction of our globe by shattering it in pieces in the collision, or burning it up in a grand conflagration.

Amongst the Arabs, the year 902 is still called the Year of the Stars, because of the large number of falling stars which were observed on the night in October on which the Caliph Ibraham-ben-Ahmed died, and as recently as Feb. 9, 1865, when a large meteor was seen at Salem, in the Carnatic, the Hindoos declared that a king was about to die, their belief in this idea being no doubt greatly strengthened by it so happening that the Rajah of Mysore did then die.

It is but natural to anticipate that the fall of any heavy body from the clear heavens above us, could not take place without making a deep and lasting impression on those who witnessed its descent, so that it is easy to understand how, in the early ages, aerolites came to be regarded with extreme veneration. Herodian informs us that at Emesa, in Syria, a large black conical meteoric stone was, from its having fallen from the clouds, worshipped as the representative of the sun, and that this stone was afterwards brought with great pomp to Rome by Elagabalus, the high priest of its temple. In the Parian chronicle, also, it is recorded, that the mother of the gods was adored at Pessinus, in Galatia, under the form of a stone which had fallen from heaven, and which was regarded with such reverence that a treaty was made by the Romans with Attalus, King of Pergamus, for its acquisition, in virtue of which it was solemnly brought to Rome, and placed in the temple of Cybele by Publius Scipio Nasica, about 204 years before the Christian era. In other parts of the world we find, in like manner, that the celebrated Pallas meteorite was for a long time revered by the Tartars of Siberia as a heavenly relic; and more recently the African traveller, Dr. Barth, found that the natives of Turuma, in Eastern Africa, worshipped a stone which had fallen from the sky with the accompaniment of thunder, over which they had built a rude temple, in which they anointed it with oil, and made offerings of glass beads. On his first visit Dr. Barth was not even allowed to see it; but some three years later, when the country was devastated by war and famine, he managed to secure possession of it, and in 1859 deposited it in Munich.

The notion that meteoric stones contained within them hidden treasures seems to have been prevalent in some parts of Europe, an idea which may possibly have suggested itself from the known custom, in still older times, of secreting valuables within images of the gods to protect them from pillage; but, be that as it may, instances of meteoric falls are recorded, even in this century, in which the spectators, once recovered from the mortal fright occasioned by the phenomenon, have allowed their cupidity to overcome their veneration, by smashing the newly-arrived stone into fragments, in order to see whether it did not contain gold or precious stones within it.

If this idea obtained amongst the prehistoric inhabitants of the earth, which however is unlikely, the disappointment experienced on their not finding gold within would, in many instances, be more than compensated for by the discovery that they contained a metal infinitely more valuable to them than gold, viz. native iron, easy of being shaped, even with their rude stone implements, into cutting tools excelling anything they previously owned. There cannot be a doubt as to the meteoric origin of the first iron implements, and that this was ages before the art of extracting iron from its ores had been perfected. The iron weapons mentioned by Homer as in use at the time of the siege of Troy, some eleven centuries before the Christian era, were most probably made from meteoric iron, which would account for the enormous value, as compared with other metals, which was at that early period put upon them. In the Greek mythology we are also told that the thunderbolts of Jupiter were forged by Vulcan, which would indicate the knowledge that meteorites were at times composed of iron; and it is not unfair to suppose something more than a mere accidental coincidence in the Latin word "sideres," "the stars," resembling so much the Greek for iron, *σιδηρος*—a coincidence possibly arising from the observation that certain stars seen to fall to the ground were composed of meteoric iron.

According to Mongolian traditions, a black mass of rock, some forty feet in height, fell in a plain near the sources of the Yellow River, in Western China; and we read in Eastern stories of magic swords forged from iron which had but recently fallen from heaven, a manufacture which was imitated by Captain Sowerby, who some half century ago had one made of meteoric iron, and presented it to the Emperor Alexander of Russia.

It is quite certain, however, that in many parts of the globe the first iron known to the inhabitants was a meteoric product—as for example in Mexico, where iron had never been smelted, the Indians of Toluca employed for making their agricultural implements meteorites which had fallen in very large numbers in that district; in Siberia the Jakuts also use similar iron for their weapons; and in the British Museum there can be seen a harpoon and rude knife from the Esquimaux of Western Greenland, formed of pieces of meteorites flattened out and fixed in bone handles. These were obtained in 1819, by Captain, now General Sir Edward Sabine, to whom the natives explained that the iron was partly broken off a large mass and in part obtained by breaking up stones containing fragments or globules of native iron disseminated in the mass, which they then flattened out between two stones, in order to give them the proper shape and edge. The meteoric origin of these specimens was confirmed by the analysis of Mr. Brande.

In historical times it appears that the Chinese were the first to study meteoric phenomena, and their astronomical literature contains a record of meteors observed during more than two thousand four hundred years. Of this a translation has been made, embracing observations made from the seventh century before Christ down to the seventeenth century of the Christian era, which is now found of great service to modern astronomers, and the completeness of which may be appreciated when it is mentioned that no less than 1479 meteors are registered between the years 960 and 1270 of our era.

The Greek and Roman authors paid but little attention to the observation or recording of natural phenomena, yet occasional mention of meteoric falls is to be found in their writings. A shower of aerolites is evidently intended by Æschylus, when, in 'Prometheus Unbound,' he alludes to Jupiter drawing a cloud together, and covering the land with a shower of rounded stones instead of hail. Livy mentions a shower of stones which fell on the Alban Mount near Rome, about 654 years before Christ, in the reign of Tullus Hostilius. Plutarch, in his life of Lysander, describes the appearance of a meteor, about 405 years B.C., from which, at Ægos Potamos in the Hellespont, near the modern town of Gallipoli, a stone fell, which is also mentioned by the Elder Pliny as being visible in his time (500 years later), when it was as large as a waggon, and had externally the appearance of having been burnt. In the early part of the Christian era and during the Middle Ages, at least in Europe, the records of the fall of meteorites are extremely meagre, and only some seventy falls are noted up to the year 1500, of which the only one now preserved is that which fell at Ensisheim in Alsace, in 1492, in a wheat-field, of which an account was ordered to be drawn up by the Emperor Maximilian. The stone itself, weighing 270 lbs., remained 300 years hung up by a chain near the altar in the church at Ensisheim, until the French Revolution, when it was carried to Colmar, and pieces broken from it, one of which is still in the collection of the Jardin des Plantes at Paris; the remainder was, however, sent back to the church at Ensisheim, where it now remains.

Notwithstanding the numbers of well-attested cases of meteoric falls, it is strange to find these wonderful phenomena, as it were, quite ignored by the astronomers and other learned men of the last century; and as a proof of the apathy evinced by those of France in particular, it may be mentioned that on the occasion of the remarkable and well-authenticated meteoric fall of the 13th September, 1768, the three stones, or rather fragments of only one aerolite, notwithstanding their being found at three places so distant from one another as to form a triangle of 180 miles on each side, were sent to Paris for the consideration of the Royal Academy; but the subject was not considered by that learned body as worthy of their attention.

The arrival in 1777, in St. Petersburg, of the great mass of meteoric iron, weighing some 1500 lbs., discovered by the Naturalist Pallas, in Siberia, gave rise to many speculations as to its origin, and ultimately to Chladni's memoir (Riga, 1794), which at first was received almost with derision, the idea of this mass having fallen from the heavens, which he maintained, being literally laughed at. The heavens, however, may be said to have come to his aid, for it was only about two months after the publication of his work that a shower of aerolites occurred at Sienna, in Tuscany, nineteen of which were secured, one of them having cut through the hat of a boy, severely wounding him; and in the following year a meteoric stone (subsequently obtained by the British Museum), weighing 56 lbs., fell at Wold, in Yorkshire. Sir Joseph Banks, then President of the Royal Society, called attention in the same year to the similarity of this aerolite with a specimen of those from Sienna which he had recently received; and later, in 1799, did the same with regard to another, which had broken through the roof of a house at Benares, in Hindostan, subsequently analyzed by Howard. The French men of science, however, were not to be convinced as yet; for even as late as 1803, M. De Luc wrote derisively, "I believe, since you declare you have seen it, but I would not believe had I seen it myself." On the 26th April, this same year, however, at 1 P.M., and under a clear sky, there fell at L'Aigle in Normandy, a shower of aerolites estimated to exceed 3000 in number, of all sizes, from $\frac{1}{4}$ of an ounce to 17 lbs. in weight, causing such consternation that the Government despatched the celebrated Biot to report on the circumstances, the results of which—in conjunction with the analyses made by the chemists Vauquelin and Thenard, who found them to have the same chemical composition as the meteorite from Benares, previously analyzed by Howard—were so conclusive as to set all questions at rest for the future, even in France, as to the possibility of stones actually falling from heaven, and to cause the translation of Chladni's memoir into French.

The study of meteoric phenomena henceforth assumed an importance not previously attached to it. The appearance and attendant phenomena of meteoric falls were now registered, and the stones themselves carefully preserved and examined; and it may be mentioned that at least one, if not more, of the meteorites which have fallen in each successive year from 1803 to 1871 (the years 1816, 1817, 1833 and 1845 alone excepted) are now to be met with, either in public or private collections.

After this historical sketch of the subject, we may proceed to consider the main features connected with the fall of meteorites. All of you have no doubt often witnessed shooting or falling stars, especially during the great meteoric displays which occur in the middle of the month of November, and will have noticed how one of them, appearing in the distance as a mere luminous point like an ordinary star, becoming, as it approaches nearer, larger and larger, until it looks like a globe of fire surrounded by a brilliant vapour, and having a tail like a comet. In the day-time, however, on account of the sun's light, and the emission of smoke and vapour from the meteor itself, it often assumes the appearance of a small cloud of singular form and colour, and in both cases ultimately bursts with an explosion. The apparent size of meteors is very deceptive, even when measurements are attempted based on the angle made by their apparent diameter and their calculated distance, the reason being that the apparent diameter is not that of the solid meteorite itself, but only of the photosphere or illuminated atmosphere which surrounds it; for this reason we often find them described as being even as large as the full moon for example, although the bulk of the meteorite when fallen is seen to bear no relation whatever to such a size. It is rarely, however, that this test can be applied, as most commonly the meteors, when they enter our atmosphere, or soon after, burst with a terrific explosion, scattering their fragments, often thousands in number, over a vast area, and frequently miles apart. At this moment it occasionally happens that the fragments themselves, whilst still in the air, assume the appearance of so many distinct meteors in the act of falling to the ground. The noise of the accompanying explosion has on different occasions been likened to the roll of thunder or of drums, the report of artillery, rattle of musketry, or the rumbling of a heavy waggon or train over a bridge; and after lasting several minutes, this noise is often followed by a whistling sound, like that heard when a stone is thrown out of a sling, which is caused by the rush through the air of the stone or its fragments as it descends to the earth, into which it may bury itself several yards if the ground be soft, or if meeting rock may be itself shattered into fragments by the collision. The branches of trees are often broken, and the decks of ships or roofs of houses penetrated, and there are numerous instances of life having been lost, animals or men having been struck down by the stones. Two monks were thus killed at Cremona and Milan, in Italy; and it is recorded that an aerolite, weighing 8 lbs., falling on board ship at Rochfort, in France, 1614, killed two Swedish sailors.

The light emitted by these fireballs or meteors is extremely bright, especially by those which travel in a more oblique or horizontal direction. In some instances the light appears to have been even more powerful than that of the sun, as objects have been known to throw shadows in bright daylight when a meteor has been seen in the heavens; more generally it has been compared in brightness to that of a planet, or to the electric or magnesium light, frequently, like the latter, leaving a bright track or trail behind it remaining visible to the eye for several seconds or minutes after the passage of the body itself. Whether this is merely an impression left on the retina, or ocular deception, or is due to finely divided highly incandescent solid matter thrown off from the meteor, as is seen on a small scale with the magnesium light, is a problem as yet unsolved. The colour of the light is usually white next the zenith, changing to bluish or sometimes reddish over the horizon, the nucleus being oftener red or deep orange, whilst the tail is bluish or more rarely reddish. The meteors of Nov. 7, 1799, and Oct. 23, 1801, emitted a greenish light, thought by some to indicate the presence of copper. Although the majority of meteors seen in Europe show primitive colours, it appears from the Chinese records that lilac and other compound colours are more frequent in that country.

The luminosity of meteors is not regarded as due to their being actually burning bodies, but is usually attributed to their being surrounded by an atmosphere rendered luminous through the enormous pressure due to the rate at which they fly through the heavens (a velocity of twenty miles per second being equal to a pressure of 100,000 atmospheres); an explanation not altogether satisfactory however, seeing that whilst they are observed to be less luminous after entering our atmosphere, they are very brilliant at altitudes beyond it where the air must be so rarefied as to be nearly a vacuum not containing $\frac{1}{100000}$ of oxygen; a difficulty which made Poisson suggest that the luminosity of meteors might be due to electrical phenomena. Various calculations make the velocity of meteors to be from sixteen to thirty-two miles per second. It is evidently greater than that of the earth's rotation, since meteors are often seen to, as it were, catch up and outstrip the earth. The enormous resistance which bodies moving at such high speeds must encounter from the air, when they once enter our atmosphere, sufficiently explains why they do not do greater damage, or why, as at Hessle in Sweden, the two pound stone which fell on the ice only scored it up some three or four inches, and rebounded, instead of breaking through it. Several meteorites, and especially the one last referred to, contain considerable carbonaceous or combustible matter, and this may possibly explain why, in certain instances, meteorites have been seen to fall or burst into fragments, and apparently burn away without leaving any or but very little solid matter behind.

Meteorites are known to have fallen in all climates, seasons of the year, and hours of the day and night, but any generalization on these points in the present incomplete state of our knowledge would be premature; it being only comparatively of late years that attention has been directed to their registration, which in itself explains why only about 100 falls were recorded between the years 1000 and 1800, a period of eight centuries, whilst no less than 191 have already been observed in the first sixty years of the present century, and it is more than probable that a far larger number fall into the sea, at night, and in out-of-the-way places, than those which come under scientific observation. Schreibers, however, taking the number of instances recorded in the quarter of a century between 1790 and 1815, and the relation of the surface area on which they fell to that of the entire earth, showed that about 700 meteorites fell per annum, which is equivalent to about one in each year on a tract of country as large as Great Britain and France united, an estimate which is probably under the truth.

Turning now to the chemical and mineralogical composition of meteorites, it may be premised that, in these respects, they are so distinct from any known terrestrial product as not to lead to any risk of their being confounded with such, and also that meteoric stones pertaining to each of the three different classes of meteorites about to be mentioned possess a wonderful resemblance to one another, quite irrespective of the part of the world they may come from.

The three classes into which meteorites are divided are called—

Aerolites proper, *i.e.* atmospheric stones or rocks;

Siderites, or masses of meteoric iron; and

Siderolites, which are a mixture of both the former.

The stones of all these classes are, upon touching the earth, found to be extremely hot, and the more so in proportion as they are good conductors. The siderites which fell at Agram were almost on the point of fusion; whilst aerolites have sometimes been found semi-plastic, so as to receive impressions from or even entangle substances on which they have fallen; the sole exception we know of being that of a stone which fell at Dhurmsalla in the Punjaub, which the coolies who picked it up declared to have been so cold as to benumb their fingers and make them instantly drop it,—a statement strangely at variance with the vitreous black glaze on its exterior, due to the rapid fusion of its exterior in its passage through the air—and the whole reminds us of the celebrated Chinese delicacy "baked ice." This black glaze, or varnish as it is sometimes called, is so characteristic of aerolites, that only one exception is known (from Chantonnay). It is usually so thin as not to attain the thickness of an egg-shell, and frequently covers the exterior of stones, which, from their shape, are evidently only fragments of larger masses, so that it must have formed after the explosion which shattered the parent mass; and here it may be remarked, that aerolites when found are rarely entire; thus for example, at Gurucpoor, in 1861, stones obtained, after the explosion of the meteor, miles apart, were found to fit into one another, and had evidently formed part of one large mass.

Mineralogically, the siderites or metallic meteorites consist mainly of an alloy of iron with from one to fifteen per cent. of nickel,—an alloy altogether different in chemical composition and physical structure from any known product of terrestrial origin, whether natural or artificial. This nickeliferous iron, owing to its being less oxidizable than pure iron, is capable of resisting atmospheric influences for periods in which similar masses of ordinary iron would have rusted away into powder; and it is mainly for this reason, in conjunction with its superior toughness, which prevents its being easily broken in its descent to the earth as aerolites do, that most of the largest metorites now known belong to the class of siderites—as, for example, one at Bahia in Brazil, weighing nearly 7 tons; another in the Chaco, also in South America, estimated at 13 tons; and the largest of all the known meteorites, which a few months ago was brought back from Ofivak in Greenland by the Swedish Arctic Expedition, which I have examined, and which is calculated to be some 22 tons in weight. Imbedded in such masses of native iron are occasionally found the minerals Troilite and Schreibersite, the first a combination of iron and sulphur, and the latter of iron and nickel with phosphorus, neither of which have as yet been met with on earth; and in addition to these several silicates, particularly olivine and others containing magnesia, which constitute the mass of the stony meteorites or aerolites proper. These latter, owing to their much greater brittleness, are more liable to be shattered to pieces either by the aerial explosion, or in the act of falling, and therefore are not often found of such dimensions as the siderites. Amongst the largest known may be mentioned the one recorded by Pliny, which was of the size of two millstones; the largest of about 1000 fragments which fell at Knyahinya, which weighed 550 lbs.; the Ensisheim and Juvenas stones respectively 280 and 240 lbs., and probably also the one which fell at Fezzan on the 25th Dec., 1869, said to weigh nearly three tons.

Instead of reading out a list of all the minerals which are found in meteorites, I will merely state that it includes metallic compounds of iron with nickel; sulphur; carbon in the forms of graphite and hydrocarbons, some six distinct silicates, three sulphides, one phosphide, five oxides, and a mineral Osbornite whose composition is unknown; besides these, Gypsum, Epsomite, calcite, apatite, Titanite and the chlorides of iron, sodium, potassium and ammonium, have been met with, but may be regarded as somewhat doubtful, or due to the subsequent alteration of the original mineral constituents of the meteorite by exposure. The mineral species which have been found in meteorites are as follows:—Sulphur; Carbon amorphous and graphitic; Bitumen, a crystallizable hydrocarbon; Osbornite; Chladnite; Enstatite (Bronzite, Piddingtonite), Lancite?; Augite; Olivine; Anorthite?; Labradorite?; Tridymite?; Chromite; Magnetite; Cassiterite; Titanoferrite?; Troilite, Pyrrhotine?; Oldhamite; Schreibersite; Metallic iron containing carbon called Campbellite and Calypite by Meunier, and the alloys of iron with nickel to which the names Tænite, Kamacite, Plessite, and Octibhehite have been applied by the same mineralogist.

A review of the chemistry of meteorites teaches us that they are composed only of those elements which we know to exist on earth, and as they have not afforded us any new element, we may conclude that the more distant parts of the universe are also composed of the same elements as our globe. Of these elements (in all sixty-four) nineteen have been proved to occur in meteorites, which consist of of six non-metallic bodies: Silicon, Carbon, Sulphur, Phosphorus, Oxygen, and Hydrogen; five metals of the alkalies and earths—Potassium, Sodium, Aluminium, Calcium, and Magnesium; and eight other metals—Iron, Nickel, Cobalt, Manganese, Chromium, Copper, Tin, and Titanium. Traces of seven more have been reported, but may be regarded as doubtful, viz., Chlorine, Antimony, Arsenic, Lead, Glucinum, Yttrium, and Zirconium. An idea of the general per-centage composition of aerolites will be best obtained by a glance at the figures here given, which show the average of the numerical results of all the most trustworthy chemical analyses made up to date, as calculated by Reichenbach:—

Silica	40·00	Chromium	0·50
Iron	25·00	Manganese	0·33
Magnesia	20·00	Sodium	0·33
Alumina	2·00	Other elements	1·34
Sulphur	2·00	Oxygen, Hydrogen, and loss	5·50
Nickel	1·50		
Lime	1·50		100·00

One of the most extraordinary points in the chemistry of meteorites is the discovery made by the late Professor Graham, that meteoric iron contains, occluded in its substance, a large amount of hydrogen gas, which may be regarded as a sample of the atmosphere in which it was formed, and consequently as indicating cosmical conditions totally different from those which obtain on our sphere. It is also strange that the metal nickel, which is comparatively rare on earth, and never occurs in the metallic or alloyed state, should be so constant in meteorites of all classes.

We now come to the most abstruse part of our inquiry, The Origin of Meteorites—a problem which from its nature must, to a great extent at least, depend for its solution on theoretical deductions. Speculations on the origin of falling stars seem to have early engaged the mind of man, and hypotheses, often as strange as they are numerous, were brought forward to account for these phenomena. Thus the old Lithuanian mythology explains falling stars by supposing that at the birth of each infant which comes into the world, the Spinstress Werpeja, who spins the thread of its destiny, attaches a star to its extremity, which then hangs up in the heavens and shows its light as long as the being it represents lives, but with the termination of its mortal career, the thread breaks, and the star, falling to the earth, becomes extinguished.

The ancient Greek philosophers, who, although they paid but little attention to natural, and especially observational science, did not, however, neglect to occupy themselves with speculations on the origin of meteoric phenomena, and advanced several hypotheses to account for falling stars and meteorites, which it must be admitted actually contain the germs of most if not all the more modern theories. One of these hypotheses explained meteorites to be masses of matter previously raised from the earth's surface by tempests, which had again fallen down; and Plutarch mentions that Anaxagoras taught that the ether surrounding the earth is fiery in nature, and by the force of its circumvolution tears away masses of rock from the earth, sets them on fire, and turns them into stars. It is not necessary to make more than mere mention of this hypothesis; but it may be noticed as a curiosity, that in August, 1858, a supposed meteoric shower fell at Birmingham, throwing down numerous pieces of black stone, rounded on the edges, and about the size of walnuts. The chemical analysis of these, however, showed them to be fragments of the Rowley Hills basalt, which had evidently been used for macadamizing roads, and which, after having been taken up by a whirlwind, had descended subsequently by their own weight. Another suggestion was, that they originated from the condensation of vapours arising from the earth, an idea which appears to have been entertained by Kepler, and which in various modified forms has reappeared from time to time. Thus, Fusinieri imagined meteorites to be derived from gases, holding metallic matters in solution, present in the upper strata of our atmosphere, which suddenly coalesced and condensed themselves into such solids. It is hardly necessary to state that the chemical composition of the atmosphere proves it not to contain the elements of meteorites, and physically it is almost beyond conception to imagine the vast quantity of the enormously attenuated atmosphere requisite to form by its condensation a solid like the masses of meteoric iron previously referred to. Something like this idea was also brought forward much more recently in France; the supposition being that our atmosphere was charged with what was termed meteoric dust, which contained iron, nickel, and the other elements of meteorites, and from which they were formed by a similar process of condensation. It was even asserted that such dust could be collected on the summits of our higher mountains, but neither facts nor theory corroborate this hypothesis any more than the former. That they came from the sun is an opinion alluded to by Diogenes Laertius, and also by Anaxagoras, who was persecuted by the theologians of his day because he maintained that the sun must be a molten fiery mass. Pliny ridiculed this idea, but some forty years ago the late Mr. Brayley advanced the suggestion that meteorites were formed by the condensation of the gaseous emanations from the sun, and considered this view borne out by Sorby's discovery that some parts of meteorites had a structure probably due to sublimation and segregation. Still more recently, in 1870, Mr. Williams, in his work on the fuel of the sun, considers them to be solar projectiles which had passed the boundaries of the zodiacal light, and brings to his aid the recent spectroscopic discoveries of the preponderance of hydrogen in the sun's atmosphere, in connexion with the fact of that gas being found occluded in meteoric iron.

It would also appear that the ancients held the idea that the aerolites fell from the moon, for Pliny and other writers mention their watching for falls of stones from the sky during the eclipses of the moon; an occurrence which the Syrians still believe takes place on clear moonlight nights. When in later times the moon's surface was shown to be eminently volcanic, the conjecture that meteorites might be bodies projected from volcanoes in the moon became generally entertained, and was investigated by Laplace, Olbers, and others; Laplace's calculations militating against this hypothesis by showing that even if thrown out of a volcano of the moon with an initial speed of 7771 feet per second, they would require two days and a half to reach the earth, which would be a speed far less than the number of miles per second we know them actually to travel at. The same argument also refutes the idea that they might have been bodies thrown up from terrestrial volcanos which had subsequently fallen down again, independent of the fact that no such volcanic products as meteorites are known, and that the force required to project masses to such an altitude as meteorites are known to descend from is far beyond that developed by known volcanos. A century ago, when European philosophers seem rather to have shirked the investigation of many of the more abstruse natural phenomena, it was customary to regard meteorites as mere atmospheric appearances, like, for example, lightning,—an explanation which, in face of so much evidence to the contrary, is no longer entertainable; so that we must proceed to the consideration of the only remaining explanation of these phenomena, one which also had its root in the suggestion of the ancient Greeks, that they originated in celestial space as heavenly bodies which had long remained invisible, a supposition which was but little modified when, at the end of the last century, Chladni declared meteorites to be an accumulation of matter, originally created as such or fragments of larger masses, moving in space. This view was accepted by most later men of science, by whom it became gradually more and more developed, and of late years especially so, by the labours of Schiaparelli, so that the united results tend to demonstrate that falling stars, meteors, and meteorites or aerolites, are all similar bodies, differing in size, but not in composition, and that the numerous meteors which traverse the celestial space are furnished by certain if not all the comets, and probably identical with the comets themselves. These bodies, owing to the remarkable elongation of their orbits, do not appear to have formed part of our system as at first constituted, but to have been wandering nebulæ brought within the influence of the sun's action. Meteors do not belong to the planetary system, but to the stellar regions beyond, and are in reality falling stars, which bear the same relation to comets that asteroids do to planets; in both cases the smaller size is made up by the greater numbers.

The structure of aerolites shows them not to be mere masses of previously molten matter, for not only is the external vitrified glaze extremely thin, but the structure itself, instead of being homogeneous or crystalline throughout, as would have been the case had the whole been in a state of fusion, is, as a rule, seen by the eye or under the microscope to be an aggregation of fragmentary matter resembling a volcanic ash or breccia, in which, whilst some of the particles have been in a molten state (the presence of both glass and air cavities in them indicating that they were in the molten state when gases or vapours were being given off), others show no signs of fusion; so that the structure of meteorites confirms the views that they have been formed out of the débris of some previously existing larger mass, or even out of the ruins of some planetary body.

When the vastly elongated elliptical paths extending far beyond our system into stellar space, in which these bodies move, happen to cross or approach closely to our sphere, those meteors which are nearest to the earth may be drawn towards it by its attraction; and once brought within its atmosphere, their cosmical course would be abruptly terminated, and they would fall down with such rapidity as to develope by the friction and oxidating effects of the air, intense heat, whereby the external surface would be fused so as to form the vitreous glaze so peculiar to aerolites, whilst at the same time the white hot air would form a luminous envelope around them; the whole ultimately bursting with one or more explosions, either from the expansion of the gas contained or occluded within the meteorite itself, or, as has been suggested by Haidinger, from the collapse of a sort of vacuum ball formed around them.

Meunier, who has of late written more copiously than concisely on the subject of meteorites, whilst believing them to be fragments of broken-up planets, regards these bodies as but the last stage in the evolution of planetary bodies, and suggests that the moon is rapidly coming to this stage from the irregularities and incipient fissures visible on its surface, its dissolution not having taken place before, owing to its greater magnitude; arguing still further, that once broken up into fragments, these would arrange themselves concentrically according to their densities, those which before formed the central part of the planet, which he regards as most heavy and metallic, on the outside, and the others, according to their weight, in the interior. This arrangement he considers accounts for the siderites or meteoric irons having first fallen in the earliest ages of the world, then the siderolites, and afterwards the stone or aerolites proper; and owing to the meteorites of some recent falls, particularly that of Hessle in Sweden, having contained considerable carbon, he predicts the fall of a totally different class of meteorites in future. These hypotheses seem, however, to be but mere assumptions incapable of proof, for although only some very few instances of siderites having fallen in historic times are recorded, as compared to the much larger number of aerolites, still there is no proof that the proportion was different in prehistoric times, especially as it is well known that the latter would be infinitely more likely to escape observation than the former. Before concluding, although I fear I have already tried your patience too long, I would still direct your attention to one point more connected with the study of meteorites, which is the use of such bodies in the economy of nature; and unpromising and speculative as such a problem is, I may mention that two attempts, differing widely in their direction, have already been made to solve it. The first of these, made some time back by the German astronomer Mayer, and indorsed by the elaborate calculations of Sir William Thomson (who is understood, however, to have lately changed his opinions), is to the effect that the loss of heat which the sun radiates year by year from its surface, and which is so essential to the well-being of the universe, is restored to it by the continual impact of meteorites falling into its surface; and the other is the still more startling hypothesis of Sir William Thomson himself, which maintains that the origin of life on our globe (and the introduction from time to time of new species) is due to the arrival of aerolites, which, being fragments of other worlds or planets upon which life already existed, had carried with them the germs or seed, or even "living plants or animals," to populate and plant our sphere.

Not being versed in astronomy, I dare not even venture to criticize the first of these hypotheses; but as regards the second, I cannot but regard it as in the highest degree visionary and improbable, if for no other reasons than, firstly, because the now generally received theory of meteors teaches us to regard them as bodies which have been revolving probably for countless ages in space devoid of atmospheric conditions requisite to sustain life; and, secondly, because the meteorites we are acquainted with have in their descent had their external surface actually melted by the intense heat produced by the friction and oxidation of the air, so that the very supposition that any vegetable or animal being, seed or germ, could by any possibility retain its vitality or reach the earth unconsumed, seems to me in the very highest degree improbable.

NOTICES OF MEMOIRS

Austro-Hungarian Coal Supply.

Das Vorkommen, die Production und Circulation des mineralischen Brennstoffes in der Österreichisch-ungarischen Monarchie im Jahre 1868. Von F. Foetterle. (Jahrb. der k. k. geol. Reichsanst., 1870.)

The distribution, the production and consumption of coal in this monarchy is clearly shown by a large and well-executed map, which appeared a short time ago, published by order of the Austrian Government, and drawn by F. Foetterle, who also gave a short explanation of it. The map is on the scale of 1·1,296,000, and the formation to which the coal belongs is shown by five different colours. A glance at the map will convince every one of the scanty distribution of this important mineral over the enormous surface of the Austro-Hungarian dominions, and that most of the coal belongs to the western and the central districts.

a. True Coal-measures Coal is found in Bohemia, in Moravia, and Austrian Silesia, in the Alps and in the Hungarian dominions.

b. Trias and Lias Coal in the Alps, in Hungary and in the Banat.

c. Cretaceous Coal in Moravia, in the Alps, and in Hungary.

d. Eocene Coal (sometimes still showing the structure of the wood, then called Lignite, but generally a good black coal, which, when burnt, cakes, and is excellent for gas manufacture) is chiefly found in the *Alps*, where it is embedded in Cosina beds, below the Nummulite Limestone; Carpano near Albona, the large Coal-basin of the Marburg district, Sotzka, Eibiswald. The coal of Häring, in Tyrol, belongs to a higher horizon of the Eocene, as does also the coal of Monte Promina and of Sebenico in Dalmatia. The coal of Gran, in Hungary, is also of Eocene age.

e. Neogene Coal forms large basins in Moravia, Bohemia, Galicia, Bucovina, and in the north and south zones of the Alps and in Hungary.

A glance at the accompanying map of the distribution of fossil fuel in Austria shows at once how insignificant is the extent of her coal-basins in comparison with the Coal-formations of England, North America, or even Prussia.

England has	8,960	square miles of coal.
North America	100,528	,, ,, ,,
Province of Silesia in Prussia	1,280	,, ,, ,,
Austria (as near as possible)	1,200	,, ,, ,,

The whole produce of coal of all formations in Austria and Hungary amounted during 1868, in round figures, to 6,300,000 tons.

C. L. G.

REPORTS AND PROCEEDINGS.

Geological Society of London. — March 6, 1872. — Prof. Duncan, F.R.S., Vice-President, in the Chair.—The following communications were read :—1. "*Prognathodus Güntheri* (Egerton), a new Genus of Fossil Fish from the Lias of Lyme Regis." By Sir P. de M. Grey-Egerton, Bart, M.P., F.R.S., F.G.S. In this paper the author described a new form of fossil fish, having a broad premaxillary plate somewhat resembling the incisor tooth of a gigantic Rodent, a single maxillary plate like that of *Callorhynchus*, and a mandibular dental apparatus closely resembling that of *Cochliodus*. For this form he proposed the establishment of the new genus *Prognathodus*, and named the species *P. Güntheri*. *Ischyodus Johnsoni*, Agassiz, also probably belongs to this genus, as it agrees with *P. Güntheri* in the characters of the premaxillary teeth. The author was doubtful as to the exact position of this genus, which had a head extended in a horizontal instead of a vertical plane, suggesting a resemblance to *Zygœna*, but covered with hard plates like the head of a sturgeon, and exhibited in the dental apparatus the curious combination indicated above.

Discussion.—Dr. Günther pointed out the interest attaching to the dentition of this fossil fish as being an additional evidence in favour of the connexion between the Ganoid and Chimæroid forms. The existence of three teeth instead of one on each side of the jaw, as in *Ceratodus* and others, presented in it a generic character; but the type was still the same. On one point he slightly differed from the view of the author, and that was as to the application of the terms maxillary and premaxillary to the teeth. He thought the former belonged rather to the pterygo-palatine arch, and that the teeth in the front of the jaw should be regarded as vomerine. He illustrated this by reference to the jaws and dentition of sharks, Chimæroids, and certain Ganoids. In these the teeth, instead of being connected with the maxillary and premaxillary bones, were, in fact, connected with the pterygo-palatine arch. He considered that this furnished additional grounds for including all three forms in one subclass.

Mr. Etheridge made some observations as to the horizon in the Lias in which these fossil fishes occurred. He believed that nine out of ten of the Lower Lias species came out of the upper part of the *Bucklandi* limestone series. At the base of the cliff at Pinhay, Lyme Regis, are the black shales of the Rhætic beds; above them the White Lias, in which there are no fish, though they occur in the same horizon elsewhere; above these a series of shales, with *Ostrea*, and above these again shales and limestones with *Lima gigantea* and *Ammonites Bucklandi*, the whole forming the *Bucklandi* series. The fish-beds, some 8 or 10 feet thick, contain about eighty species of fishes. Above this horizon fishes are almost unknown in the Lias of Dorsetshire. At Barrow fish also occur in the *Bucklandi* series, though somewhat lower down. In other cases fish-remains seemed also restricted to certain horizons; and the exact position of such remains as these was, in his opinion, an important feature in determining their distribution both in time and space.

Sir P. Egerton corroborated Mr. Etheridge's views as to the localization of species of fish, and agreed with him as to the importance of recording the exact position of all such fossils.

Prof. Ramsay was gratified to find that these connecting links between different genera were being discovered. They seemed to him to foreshadow the time when the word 'genus' would become extinct; while at the same time the careful researches of the author and others tended more and more to establish the truth of the great theory of evolution.

2. "On two specimens of *Ischyodus*, from the Lias of Lyme Regis." By Sir P. de M. Grey-Egerton, Bart., M.P., F.R.S., F.G.S.

In this paper the author noticed a new example of the greatly developed rostrum of a male Chimæroid, an inch shorter, more slender, and more attenuated at the apex, than that of *Ischyodus orthorhinus*, Egerton, having a projecting median rib along the upper surface, and the tubercles of the lower part smaller and fewer than in *I. orthorhinus*. For this form the author proposed the name of *I. leptorhinus*. Also a dorsal fin-spine, with the cartilages to which it was articulated, showing the mechanism of its attachment very clearly. This spine differs from that of *I. orthorhinus* in being straighter and smoother, and having fewer and smaller tubercles. The author regarded it as probably belonging to *I. leptorhinus*.

3. "How the Parallel Roads of Glen Roy were formed." By Prof. James Nicol, F.G.S.

In this paper the author endeavoured to explain, in accordance with the marine theory of the origin of the parallel Roads of Glen Roy, the coincidence of the level of these terraces with that of the different cols, and also how the same sea could have produced terraces at different levels in different valleys. He assumed that during the gradual elevation of the land, the gradual closing of the straits between its separate masses by the elevation of the cols above the surface would, by checking the eastward flow of the tidal current, cause the sea-level in the western bays to remain stationary relatively to the rising land; and during this period the marine erosion would take place along a line corresponding in level to the col. Hence, in Glen Gloy, which has only one col, the highest in the system, the highest road only was formed; and Glen Gloy remained unaffected by the stoppage of those cols which produced three roads at lower levels in Glen Roy, the lowest of them also extending round Glen Spean.

Discussion.—Sir Henry James stated that he had given particular instructions to the officers in charge of the survey as to the accurate levelling of the roads. Captain White had informed him that there was some question as to the existence of more than one road in Glen Gloy. There could, however, be no doubt as to the general correspondence of the levels of the terraces at different points. With regard to local variations in the level of the sea, he stated that the mean sea-level was found to be remarkably constant. He considered the question as rather physical than geological. In that district was a country every feature of which had been modified by glaciers; and there was, therefore, no difficulty in conceding the existence of glacier lakes. There was, moreover, every probability of a country cut up by such deep valleys having in places enormous accumulations of ice. The difference in level between the beds in Glen Gloy and Roy was 20 feet, which could hardly be accounted for on the marine theory. Nor are there any similar terraces in neighbouring glens, such as ought to be there on that theory. In so exceptional a district, with Ben Nevis acting as a buttress at the south end of Glen More, against which and upon which ice would accumulate, that theory was the best which accounted for the terraces by the lakes having been formed by the intervention of glaciers blocking the valleys, as, according to this theory, it would not be likely that the levels of the roads in the different valleys would be the same, seeing that the ice-barriers of the different valleys would probably not break at the same moment. The levels were taken at the middle of the slope of the terraces.

Prof. Ramsay entered into the history of the theories for accounting for the terraces, the first of which, that of Prof. Agassiz (in 1840), accounted for them by a great glacier damming up the valley, and from time to time declining in height. The glacial theory, on which this view rested, had to some extent been doubted, but eventually had been almost universally accepted even by its first opponents. He next cited the works of the late Mr. Robert Chambers as to the existence of old sea-margins, pointing to a gradual sinking of the sea or a rising of the land. There could be little doubt that a great part of Scotland and of the northern part of England had been at one time covered with glaciers, as had also been the case in other parts of Europe. Unless the whole country had been submerged, and then come up again by a succession of jerks, it seemed impossible that such terraces could have been formed by the sea and still have remained in existence. If, however, there had been great oscillations in temperature, it seemed possible that during the decline of some transverse glacier the varying levels of the lake might have left terraces, traces of which might still be preserved.

Mr. L. Lyell thought that Prof. Nicol's view, that the different heights of the terraces in Glen Gloy and Glen Roy were due to a great pressure of water coming from the west, could hardly be sustained. If the sea had stood at that level, Scotland would have been an archipelago, and differences of level, such as the terraces indicated, could only have resulted from great tidal action, such as is the case in the Loffoden Islands. He held that there was no evidence to show that such a state of things had existed in the present case. As to the coincidence of the level of the roads with that of the cols, he did not think they were explained on the marine hypothesis. At the base of Prof. Nicol's speculation was an assumption in which he could not agree. It was that the coating of detritus which covered the hills was of marine origin. On the contrary, he held it to be sub-aërial. The fragments of rock were sub-angular, little weathered, and altogether such as might be found in any sub-aërial detritus. At Loch Assynt the beach of the freshwater lake consists of fragments of red and white sandstone, unrolled and but partially water-worn. The beach of Loch Maree, a land-locked arm of the sea, was composed of fragments of the same rocks, but these were rolled; and he believed that this difference was due to the tide, which was absent in Loch Assynt and present in Loch Maree. The materials on the roads of Glen Roy, when he examined them in 1869, much more nearly resembled those on the shores of the freshwater lake than those on the shores of the marine and tidal Loch Maree. He suggested the necessity of the observation of the nearest parallel cases which could be found in cases where no experiments were possible. The phenomena shown in Glen Roy were then compared with similar appearances at the Märjelen See, a small glacier-bound lake in Switzerland, which fulfils in nature all the conditions which the theory of the glacier-lake origin of the Glen Roy terraces required.

Mr. Gwyn Jeffreys renewed his protest against regarding these beds as marine unless marine remains were found in them. In Prof. Nicol's former paper mention had been made of rolled boulders. These occurred at Glasgow and elsewhere covered with *Balani*. As, however, no marine remains had been found in Glen Roy, he adopted the freshwater or glacier theory.

Mr. Daintree, reasoning from observations made in tropical countries, asked whether the terraces might not have been formed during the change of seasons from summer to winter.

Mr. Evans regretted that no one else was present who would in any degree advocate the author's views. He pointed out that if the surface of the rocks below the detritus in Glen Roy was glaciated, the probability was in favour of the superficial drift being of marine rather than of sub-aërial origin. He much doubted whether Ben Nevis, or any of the mountains of the district, offered a sufficient gathering-ground for any such glacier as that supposed in the freshwater theory, assuming the climate to have been such as would have admitted of a large lake in Glen Roy. He suggested the possibility of the openings through which the sea would gain access to the district having at the time of the last submergence been to some extent choked with ice, which thus checked the tidal action inland from the present coast; and thought that possibly both glaciers and the sea had together contributed towards the formation of the terraces. These, he observed, were by no means confined to Gley Roy itself, but were to be seen on a large scale, and at a lower level in the valley of the Spean, if not elsewhere.

Mr. Prestwich observed that both sides of the question had an *à priori* argument in their favour. There was no doubt of the almost universal glaciation or of the depression below the sea to a depth of at least 1000 feet, and therefore that marine action was possible. The circumstance of the cols marking the height of each terrace was, however, strongly in favour of the freshwater theory; but, on the other hand, there seemed an absence of sufficiently elevated land in the Glen Roy district for the origination of a glacier, such as was required by this theory.

The Chairman suggested the necessity of actual sections being made to show the nature of the terraces and the condition of the rocks below. He referred to a case on a much larger scale in the Yungma valley of East Nepaul, recorded by Dr. Hooker, in which the phenomena at Glen Roy were repeated on a larger scale, and, in connexion with each terrace, a glacier and its moraine could be traced.

CORRESPONDENCE.

FISH-REMAINS IN THE DEVONIAN BEDS OF CORNWALL.

Sir,—In 1868 I recognized, in Mr. Pengelly's collection of Cornish fossils at Torquay, the structure of the Upper Silurian and Old Red fish *Pteraspis* or *Scaphaspis*, in the supposed coral the *Steganodictyum Cornubicum* of McCoy. This identification was afterwards confirmed by Prof. Huxley and Mr. Ray Lankester, and it has an important signification upon the question of the age of the rocks of South Devon and Cornwall, inasmuch as the *Pteraspis* has, I understand, been found by Mr. Etheridge in the lower Devonian rocks of Lynton and Lynmouth.

As I am not aware that any further investigations have been carried on as regards the Cornish rocks, the following notes may have some interest for those amateurs in geology who, like myself, enjoy passing leisure hours in the investigation of the records of the rocks.

When on a visit to Penzance in February last, I took the opportunity of examining, through the courtesy of the Hon. Curator, the collection of Looe and Polperro fossils presented by Mr. Peach, Mr. Couch, and others, to the Museum of the Royal Geological Society of Cornwall. It appears that as early as 1846, these fossils were described by Mr. Peach as the remains of *fish*, in the *Transactions* of the Geological Society of Cornwall, from specimens found by Mr. Couch at Scilly Cove, on the east side of the harbour at Polperro. From what I saw in the Penzance Museum, I determined to examine the Looe and Polperro district, and requested my friend Sir W. Guise, who had already gone over with me the Old Red districts of Herefordshire and Monmouthshire, and the rocks of North Devon, to join me at Plymouth. Our time was limited, and I can only say that I wish we had gone earlier, for I know of no district more likely to repay the geologist for prolonged and thorough investigation. The place for head-quarters should be that romantic little town Polperro, which may be best reached from Liskeard, and where comfortable, though limited, quarters may be obtained at "The Ship." Mr. Loughrin, a ready guide and good naturalist, knows the geology of the district, and especially the localities where the fish-bed may be seen *in situ.*

As to the geological position of the beds, I was unable to determine them, as they appear to me to be faulted through the overlying Devonians of Plymouth, etc. Their dip too is reversed.

As regards mineralogical character, the fish-bearing slates look like some beds shown me by Mr. Pengelly at Mudstone Bay, near Torbay, and which are there faulted through the Torbay strata. In these Mudstone beds Mr. Pengelly, I believe, has found fish-remains. Mr. Etheridge, Palæontologist to the Geological Survey, considers the Polperro and Looe rocks are on the same horizon as the Lynton and Lynmouth strata, and I think this is very likely, more especially as at Lantiret Bay, between Polperro and Fowey, they pass into red slaty beds and yellowish grits, which are not unlike the base of the Countesbury and Foreland beds at Lynton; the Lantiret-Countesbury beds (if such they are) being denuded by the action of the sea near the junction with the bone-bed. My friend, Dr. Holl, thinks that the Polperro are not much above the Plymouth limestones.

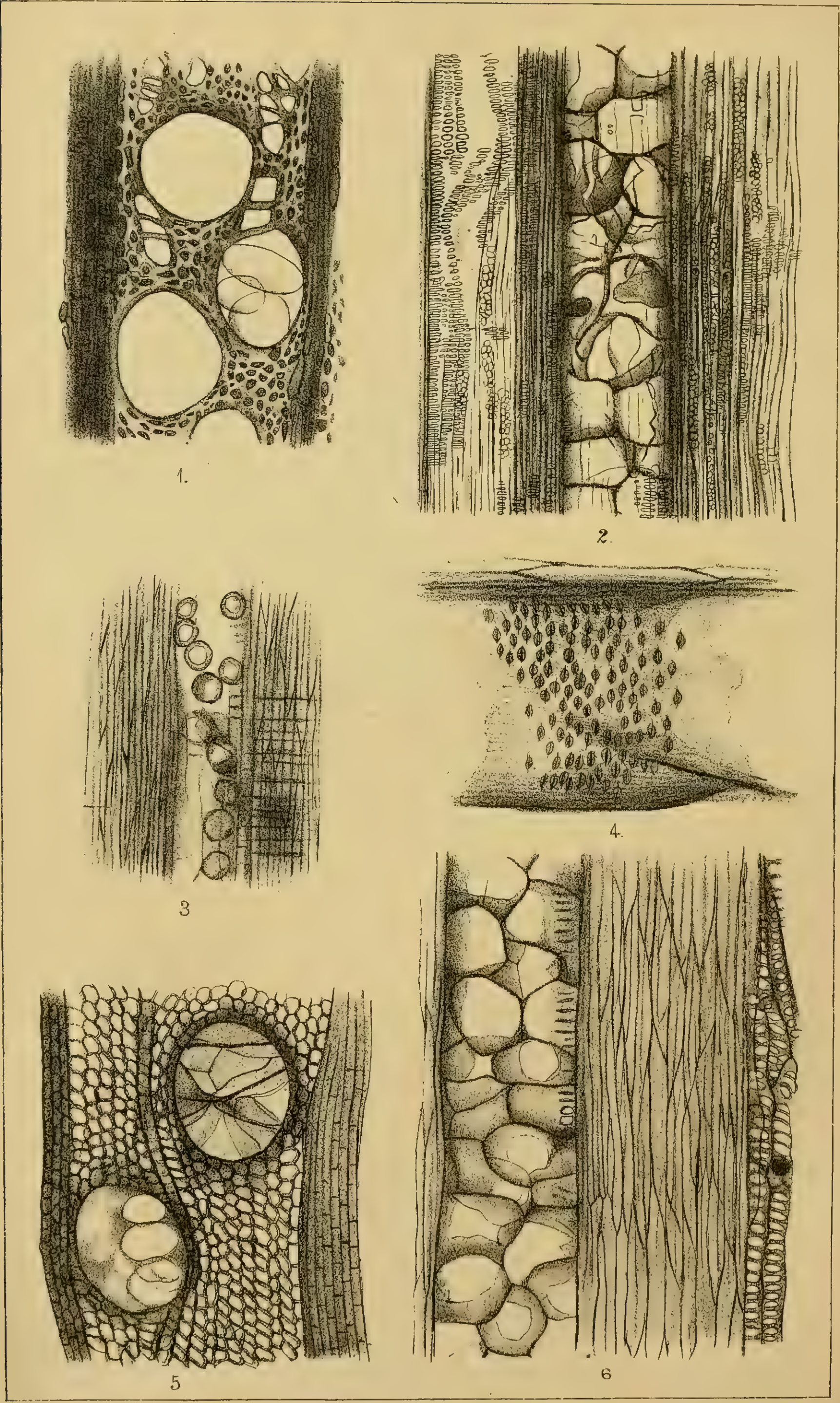
Pendock, Tewkesbury, W. S. Symonds.
18*th March*, 1872.

[In reference to the occurrence of Devonian Fish-remains at Lynmouth, it may be stated that Mr. J. Wetherell of that village has found a number of these in the rocks to the West of Lynmouth, where the blocks on the shore are exposed to the action of the sea. A notice of their occurrence was read by Dr. Fairbank to the Geological Society of London, Nov. 23rd, 1870, but the paper has not been published. See abstract, Geol. Mag., 1871, Vol. VIII., p. 38. See also notice of Fish-remains in Cornwall, Geol. Mag., 1868, Vol. V., pp. 247, 296, and 437.—Edit. Geol. Mag.]

Geological Survey Appointments.—In our notice of last month we stated that Mr. Bristow had been appointed "Local Director" instead of *Senior Director* for England and Wales. We may add that Mr. H. H. Howell, F.G.S., has been promoted to the post of District Surveyor, and Mr. J. Clifton Ward, F.G.S., has been appointed a Geologist on the English staff.

OBITUARY.

We regret to have to record the somewhat sudden death of Dr. Auguste Krantz, of Bonn-on-the-Rhine, who died from an attack of *erysipelas* during a visit to Berlin on the 6th April last. Dr. Krantz of Bonn represents one of the longest established and most able members of that rare class, a scientific merchant in rocks, fossils, and minerals—one, who not only knew accurately the commercial value of his collections, but was intimately acquainted with the scientific worth of every specimen which passed through his hands. Indeed, there are few museums which have not been enriched from his cosmopolitan repository. He leaves an immense and valuable collection both of Minerals and Fossils, the result of the labours of a long life devoted to these pursuits. Dr. Krantz was in his 62nd year. We believe it is the intention of Madame Krantz to carry on her husband's business, with which she is well acquainted.



A. T. Hollick del. et lith. Mintern Bros. imp.

Tylose in Tertiary wood from Thanet.

THE

GEOLOGICAL MAGAZINE.

No. XCVI.—JUNE, 1872.

ORIGINAL ARTICLES.

I.—On some Fossil Wood from the Lower Eocene.

By W. T. Thiselton Dyer, B.A., B.Sc., F.L.S.

(Plate VI.)

THE Botanical Department of the British Museum possesses amongst its collection of fossilized vegetable remains, sliced for microscopic examination, a series of specimens of wood from Herne Bay and the Isle of Thanet. These exhibit a structure which has not hitherto been properly understood, but which proves to be quite comparable with what is to be found in some recent plants.

Fossil wood from this locality has long been known to collectors. Mr. S. Gray gave the following account of it in the *Philosophical Transactions*, in 1700[1]:—"About half a mile from Reculver, towards Herm, there appears in the cliff a strata of shells in a greenish sand; they seem to be firm, but some of them are entire, but when you go to take them from their beds they crumble to powder between your fingers; but that which is most remarkable is, that in the lower part of the strata, where the shells are more thickly dispersed, there lies scattered up and down portions of roots, trunks, and branches of trees; the wood is become as black as coal, and so rotten that large pieces of it are easily broken with one's fingers. I know not what depth these may lie, the strata's surface not appearing above two feet from the beach, but I judge it from the superficies or top of the cliff above 12 foot. I saw the stump of one tree standing upright, broken off about a foot from the ground. I should have given a more particular account, but cannot find at present the note I took upon the place. I shall only add that the shells were of the white Conchites."

Mr. Dowker states that in the neighbourhood of Reculver large masses of silicified wood, often bored by *Teredo*, are found both in the Woolwich beds and in the Thanet sands.[2]

The microscopic structure of the wood shows at once that it belonged to an arborescent Dicotyledon. Fig. 1 (Pl. VI.) represents a transverse section of a "wedge" which is bounded on either side by a medullary ray, and consists of woody tissue and large ducts. The woody tissue is made up for the most part, as is usually the case,

[1] vol. xxii., p. 762.

[2] Proc. Geol. Asso., vol. i., p. 343.

of long prosenchymatous fibrous cells. Adjacent, however, to the ducts there are often found in the wood of plants cells of what has been termed wood-parenchyma, which are shorter and less obliquely truncated than the prosenchymatous wood-cells, and are also conspicuously marked with pores corresponding to those seen on the walls of the duct. This wood-parenchyma is clearly shown in Fig. 6, on the right hand side of the figure, which is drawn from the Vine for the sake of comparison. In the Thanet fossil wood the vessels were also surrounded by short-celled wood-parenchyma, the walls of which were marked by large slit-like pores, which stretched in a somewhat scalariform manner across each face of the cells. This is the explanation of the slit-like markings to be seen amongst the wood-cells in Fig. 2; the artist has drawn the specimen faithfully as he saw it, and the markings were more distinguishable in this particular specimen than the cells to which they belonged. The smaller circular bodies delineated amongst or rather in the wood-cells in the same figure represent, I think, not improbably starch granules. It only occurred to me after I had arrived at this conclusion, that Mr. Carruthers had ascertained that the form and arrangement of starch granules in the cells was also admirably preserved in the stem of a fossil fern, *Osmundites Dowkeri*, from the same locality and geological horizon.[1]

The most curious feature about this wood is, however, the cellular mass (Tylose) with which the interior of the ducts is filled up; this is shown very characteristically in Fig. 2. Dr. Bowerbank made this anomalous structure the subject of a paper in the first volume of the *Transactions* of the Microscopical Society of London.[2] The material upon which he worked was a fossil wood from the London Clay, which appears from its structure to have been identical with that from Herne Bay. In both cases the included vesicles vary in size, being often, as in Fig. 3, small and not so large as to compress one another. His conclusion was, that "it appears probable that the whole of them may be attributed to a more than ordinary development of the globules of circulation, analogous to those observed in *Vallisneria* and other plants."

Dr. Arthur Farre, in a subsequent paper in the same volume, followed up Dr. Bowerbank's view as to the origination of these vesicular bodies from the *contents* of the duct, but thought that they might have originated by a process of "balling" similar to that by which the endochrome of *Nitella*, when it begins to decay, breaks up into globular masses with a brownish investment. He remarks with judicious caution that "these brown globules contained in the stems of *Nitella*, appear to differ from the globules found in the vessels of the fossil wood chiefly in the circumstance of their being hollow spheres

[1] Quart. Journ. Geol. Soc., vol. xxvi., pl. xxv. Amylaceous structure is also shown in the Fern-structures described by Renault, from Autun (Carboniferous), Ann. d. Sc. Nat., 1869.

[2] On a New Variety of Vascular Tissue found in a Fossil Wood from the London Clay, pp. 16-18. (1844.)

in the fossil, but capsules filled with green matter in the recent plant." (p. 22.)

Many instances of Tylose are now known amongst recent plants, and have been repeatedly made the subject of investigation by foreign writers, Malpighi, indeed, in his "Anatome Plantarum,"[1] gives a very fair representation of them in the oak (tab. 6), remarking (p. 9), "fistulæ frequenter *pulmonares* quasi *vesiculas* trachearum substantia excitatas continent." Without going into the literature of the subject, which is considerable, it is sufficient to state that the investigations of an anonymous writer in the *Botan. Zeit.* for 1845,[2] confirmed by Mohl[3] and Reess (*Bot. Zeit.*, 1868), appear to leave little doubt that the "Thyllen," as the first-mentioned writer named them, are hernioid protrusions into the vessel from adjacent cells. In the words of Reess, "each young Thylle makes its appearance as a bulging of a wood-parenchymatous or medullary-ray cell forced through a pore in the vessels." This process would be inconceivable in the case of the prosenchymatous cells; but parenchymatous cells, such as those mentioned above, which surround the ducts, and those which form the medullary rays, do not undergo the same amount of speedy induration. In Figs. 5 and 6 transverse and longitudinal sections are given of the wood of the vine, showing that the "Thyllen" are precisely comparable in this and in the Eocene wood (Figs. 1 and 2). Mr. Sorby has also figured in the third vol. of the *Mic. Soc. Trans.* (pp. 91–92) a "non-gymnospermous exogenous wood" from the Lias near Bristol, which shows evident traces of Tylose.

Fig. 4 represents a portion of the wall of the ducts from the Thanet wood, to show the arrangement and character of the pores. These are, as is well known, formed by intermissions in the internal thickening which the walls of the ducts (as of other cells) undergo. They are therefore closed externally by the primary membrane of the duct, and this must, therefore, undergo rupture or resorption before the Thyllen can be developed. The pattern of these pores is peculiar, but not uncommon. Dr. Bowerbank founded upon them an affinity of the London Clay wood to the genus *Piper*. Similar pores are, however, figured by Sachs, in the widely remote *Dahlia*.

Prof. Van Heurck, of Antwerp, has used the term Tylose for the structure termed by German writers "Thyllen."[4] I think, as the former word will anglicize more conveniently than the latter, we may follow his example.

*** Fig. 4 is magnified about 250, the rest about 120 diams.

[1] 1686, vol. i.

[2] Prof. Van Heurck, informs me that this paper, signed "von einem Ungenannten," was written by Mdlle. la baronne Hermine von Reichenbach. See, for an abstract, Ray Soc. Rep., 1849, p. 237.

[3] See Ray Soc. Rep., 1849, pp. 26, 27. Mohl found Tylose in Palms; the structure is therefore not peculiar to Dicotyledons.

[4] Sachs, Lehrbuch d. Bot., 1870, p. 27, calls them Tullen.

II.—Notes on the late Eruption of Vesuvius.

By G. Poulett Scrope, F.R.S., F.G.S., etc., etc.

THE Eruptions of Vesuvius naturally create a wider and deeper interest than those of any other volcano, owing to the mountain lying within sight and hearing of one of the most populous and frequented cities of Europe. And in these days of telegraphs and newspaper correspondence the mingled feelings of alarm and admiration which these phenomena excite at Naples are rapidly spread over the civilized world, tinged with all the exaggerations and embellishments that the imagination of writers, who, probably, witness an eruption for the first time, can bestow on them.

This has been in a marked degree the case with the recent eruption, which, beginning on the 26th of April, began to decline on the 28th, and terminated on the 2nd of May, and therefore in point of duration by no means equalled several outbursts of the same mountain that have occurred during the last century. That of 1793-4 lasted a year and a half. The eruption of 1822 continued with great violence through more than 20 days; that of 1834 twenty-four days; that of 1850 nearly a month. True, the violence of an eruption is not always to be measured by its duration, since moderate discharges of vapour and scoriæ, accompanying the emission of minor lava-streams, have sometimes gone on for months together in the intervals between the more powerful eruptive paroxysms. In the present instance indeed the vigour of the eruption seems to have been largely out of proportion to its limited duration, although by no means equalling in this respect some of those we have mentioned above, as is well known to those who are acquainted with the admirable volume of Professor Phillips.

The cone of Vesuvius had been continually increasing both in height and bulk since its truncation by the great eruption of 1822, and in place of the deep and wide crater then formed, and repeatedly filled up, and to some extent reformed, by subsequent eruptions of minor violence, an upper cone had risen, giving a pointed apex to the mountain. This subsidiary cone was in almost constant activity throughout the year 1871, steam and scoriæ being continuously ejected from its crater, while small streams of lava occasionally flowed out of it, and found their way down to the northern foot of the great cone, where they accumulated in or about the Atrio. This state of moderately tranquil activity lasted through the first months of this year, proving that up to that time the lava still occupied the highest part of the chimney of the volcano in a state of more or less fluid ebullition.

Suddenly, on the morning of the 26th April, a violent earth-shock was felt throughout the area of the mountain, and fearful detonations and incessant rumbling noises, accompanied by other shocks, were heard to proceed from the summit, which at the same time threw up a lofty fountain of steam and stones. A paroxysmal eruption had evidently commenced. The subterranean energy, residing in the lower depths of the volcanic focus, had increased to a point at which the minor extravasations and ejections that had been so long going on from the summit, could not suffice for its relief. Violent ebullitions broke forth at some point in these lower recesses of the volcanic chimney, and with terrific eructation the evacuation of the contents of all its upper portion began. Shock succeeded shock, till those who looked at the mountain from a distance saw the colossal trunk of the pine-cloud reaching to a height of many thousand feet above the mountain top, in the usual double ascending column, one of white globular masses of vapour, the other of scoriæ black by day, but red-hot by night; while streams of incandescent lava gushed forth from several openings on the flank and at the base of the great cone.

Of many persons who, on the night of the 26th, ascended the mountain from Naples and its environs, for the purpose of witnessing so grand and unusual a spectacle, several who had incautiously entered the Atrio were caught by a sudden increase in the violence of the eruption and the outburst of a new stream of lava close to them, and perished miserably; the bodies of some never being recovered. This stream of lava flowed rapidly at first down the south-western slope of the mountain, below the Hermitage, and by its advance the entire village of San Sebastiano and a portion of that of Massa were destroyed. The population of Torre del Greco, Resina, and the other towns which line the sea-coast at the base of the mountain, naturally supposed themselves in danger of the same fate, and, deserting their homes, crowded the road to Naples. Their fears, however, proved groundless, since the lava stopped its course two miles short of Torre del Greco. The roaring and shocks of the detonations were especially loud and fearful, as heard and felt even at Naples—more so, it is said, than on any former occasion within living memory. They were particularly violent on the 26th, and again on the 29th, by which last day, however, the force of the eruption had in other respects considerably diminished. Even on the 27th the outflow of lava had apparently ceased. The other phenomena, namely, the ejection of scoriæ and ash from the main vent, continued some days longer, and increased, if not in violence, at least in their unpleasant character to the inhabitants of Naples. The wind, which had up to that time blown from the S.W., changed to S.E. on the 29th, and brought the cloud of ashes over Naples, obscuring the light of the sun, and giving to the atmosphere the appearance of a London smoky fog. This fine dust fell in the streets and on the house-tops to the depth of an inch or more, and heavy rains accompanying its fall, made the circumstance more disagreeable. With regard to these fragmentary ejecta, some incorrect notions are perhaps entertained, even by geological writers, who seem to suppose them to be originally thrown out from the volcano in the comminuted state in which they finally fall to the ground. The fact I believe to be that they are first thrown up by the explosions, proceeding from the surface of the lava within the crater, as coarse crusts (scoriæ) or even large liquid drops (bombs) of lava. These cooling and hardening in the air as they ascend, in part fall again into the yawning gulf, to be again immediately ejected by subsequent explosions; till, after repeated ascents and descents, in each of which the hurtling shower undergoes intense trituration of its component fragments against each other, their angles are worn off, and they are reduced to small rounded gravel, then to sand, and finally to almost impalpable dust, which the winds take up, sort and transport to enormous distances. Blocks of pre-existing rock, volcanic or other, which obstructed the vent before the eruption, share, of course, in this process, which distributes the ejecta of the volcano more or less plentifully around in the ratio of their size and weight. Though drifted in some places by aqueous torrents, it is not, I believe, to attrition in water, but in the air, that volcanic gravel (lapillo pozzolana, etc.) owes its bouldered character. An eruption usually finishes by the ejection, through some days or hours, of the finest dust alone; the steam bubbles that explode from the lava-surface, as it sinks within the vent, having no longer power to throw out large fragments; in the end this stifling dust chokes the explosive force altogether, and quiet succeeds; the eruption has terminated for the time.

In all these respects the late eruption of Vesuvius appears to have followed the course of that of 1822, though clearly inferior to it in violence and duration. Its effect on the form of the mountain has, no doubt, been the same, that is to say, the truncation of the cone, and the reproduction of a great crateral gulf in its centre. As yet no details have reached us to throw light on this question. We must wait the full report of Signor Palmieri on the subject from a scientific point of view. The same must be said on another point which does not come clear out of the accounts hitherto published, namely, whether any lava-streams were really emitted on this occasion from new openings in the southern flank of the mountain below the base of the old cone, as certainly happened in the eruptions of 1760, 1777, and again in that of 1861. Should such have been the fact, as some statements aver, new small cones of ejected scoriæ (boccole) will have been formed, as has always been the case, over each of the new mouths. But it not unfrequently happens that a lava-current breaking out from the summit, or some point on the side of the cone, penetrates hollow gutters within or beneath some older consolidated flow, and runs down out of sight until it forces an exit for itself at or near the base, and thus puts on the false appearance of a new eruptive mouth. The question has a rather important bearing on the security of Torre del Greco, as all previous deviations from the old established channel of eruption have been on the south side of the mountain on the line of one or more fissures radiating from the centre of the cone in that direction. So that if at any time Vesuvius should, following the example of Etna, Volcano in the Lipari group, and many other volcanos, shift its axis, it will in all probability be somewhere on the southern base of the mountain that the new crater will be formed. Naples may be considered quite safe, but Torre del Greco seems exposed not only to invasion from torrents of lava flowing down from the present eruptive vent behind, but also to the possible formation of a new one beneath it. The alarm, therefore, exhibited by its inhabitants on the occurrence of this and previous paroxysms of their unquiet and disagreeable neighbour, is not very unreasonable.

Signor Palmieri, who watched throughout with creditable constancy the progress of the eruption, from his Observatory on the Crocelle, appears by so doing to have gained a character of almost superhuman heroism among the frightened population of Naples and its environs. The philosopher must have been much amused at the fervour of his extravagant admirers, who raised him almost to the level of their adored St. Januarius; knowing as he well did, of course, the very small amount of danger that he incurred while he remained at his post, under a substantial roof, above the possible reach of any lava-stream, in a building founded on a portion of old Somma, which has certainly never been seriously disturbed for the last 1800 years. He, better than any one, knows that the phenomena of the late eruption were by no means so exceptional as our newspaper correspondents would persuade us, but of the ordinary type of moderate Vesuvian paroxysms, such as the mountain has exhibited perhaps a dozen times within the last hundred years. That, indeed, is the judgment he is said to have passed upon it.

III.—Man in the Crag.

By T. McK. Hughes, M.A., F.S.A., F.G.S.,

of the Geological Survey of England and Wales.

PARAGRAPHS have appeared in several papers announcing more or less distinctly the discovery of fossils in the Crag which bear upon them marks of human work. Having had considerable opportunities of looking into this question, I venture to offer some reasons for believing that there is not the slightest evidence for attributing the phenomena in question to the agency of man.

The case may be thus briefly stated:—Some of the Crag deposits being composed of phosphate of lime are used for the manufacture of artificial manure, and therefore a very large number of fossils are turned over. Among them we find, in various states of preservation, sharks' teeth and vertebræ, sponges, and concretionary masses of various symmetrical forms. Some of the teeth have been found perforated in such a manner that they might be strung together for ornaments, or arranged along the edge of an instrument like a saw; just as we find similar teeth employed by savage races at the present time. Spherical, oval, and pear-shaped bodies also are found with a hole through the centre such as gives them the appearance of beads or net-sinkers. The whole question then resolves itself into this: Is it impossible or improbable that nature produced these forms?—for on that assumption only can they be considered as evidence of the existence of Man in the Crag Period.

What then is the evidence? Only a few of the teeth have been found bored right through, and not nearly all of these have the perforation in the middle of the basal portion of the tooth (see Fig. 1),[1]

[1] I have borrowed the specimens, figured on pp. 248 and 249, from my friend Mr. Etheridge, who entirely agrees with me in the views expressed in this paper.

but many, indeed most of them, have the commencement of similar perforations all over the tooth wherever the enamel has not extended or has been removed. (See Fig. 2.) Other fossils of the Crag, such as the ear-bones of whales and concretionary nodules, are bored in exactly the same manner. Similar phosphatic remains in other deposits, such as the so-called coprolite-bed near Cambridge, are found to have similar perforations.

Fig. 1.

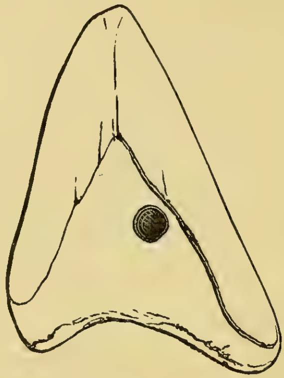


Fig. 2.

Figs. 1. and 2. Water-worn teeth of *Carcharodon*, sp. from the Suffolk Crag.

Fig. 1. Perforated through near its base by Lithodomus Mollusk (or by a *Buccinum ?*)

Fig. 2. Perforated partially by boring Mollusk.

Therefore there is not, in the position and manner of distribution of the holes, any evidence of design. Nor is there evidence of human workmanship in the character of the holes themselves. Though some of the holes are clean cut right through, the opening on one side is not always exactly opposite, or of the same size, as that on the other, and the interior of the cavity is often irregular, so that a perforating instrument, such as savages would be likely to use for the purpose, could not be pushed through from one side to the other.

Therefore the characters of the holes themselves do not point to human agency. But is there any direct evidence of other agents which may have produced the perforations ? In the phosphatic deposits at the base of the Chalk it is not uncommon to find the shells of the lithodomi which have honeycombed an ammonite or other fossil. The cavities formed by these animals are easily recognized by their shape, which is something like a sodawater-bottle. I selected a tooth from the Crag which had a hole on one side only, but which was in other respects similar to some of those which ran through. (See Fig. 3.) Mr. J. B. Jordan cut it across for me with delicate machinery, and displayed the well-known form of the lithodomus cell. (See Fig. 3*a*.)

If such a borer attacked a thin tooth imbedded in clay at the bottom of the sea, it would drill a hole clean through the tooth into the clay below; or if the tooth were more or less enveloped in concretionary phosphatic matter, which is very commonly the case, the same result would be produced. When the encasing matter was removed, the tooth would be found to be pierced by a clean-cut hole representing the middle portion of the lithodomus chamber. If the

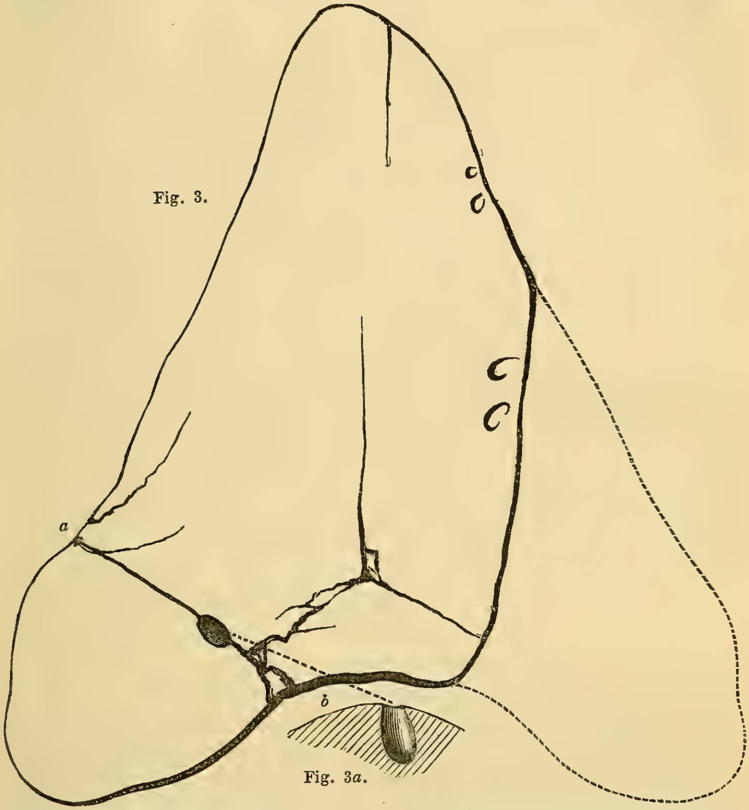


Fig. 3.

Fig. 3a.

Fig. 3. Large tooth of *Carcharodon megalodon*, Agassiz, from Crag. Outline restored by dotted line. *a b* line of section through the hole.

Fig. 3*a*. Section through lithodomus cell along the line *a b* of Fig. 3.

animal bored through the clay and only just touched the tooth, it would be eaten out into one of those basin or saucer-like cavities so common over most of these Crag fossils. Boring gasteropods, burrowing sponges, the wear and decomposition of the fossil along broken or softer and more soluble portions, must also be taken into account. From the nature of the case, therefore, we might expect to find sometimes regular, sometimes irregular cavities, as the hole was driven right through from one side only, or two holes from opposite sides were afterwards united.

Thus we have evidence that animals which could produce these holes did live in the Crag sea, and the exceptional cases where they bored through, or where the partition between two holes on opposite sides was broken through, can be easily explained.

With regard to the bead-like bodies, I may mention first of all a fact which has come under my own observation. A chalybeate spring emptied itself into a small stream which ran over a clayey bed into the marshes of North Kent. Many water weeds grew along this stream, striking their roots deep into the clay. Around these roots the iron formed concretions in the clay, especially when they were decomposing, and, when the root had perished, these concretions had the form of irregular cylindrical masses with a hole down the middle. Some of the perforated cylindrical bodies of the Crag may have had *mutatis mutandis* a similar origin. Again, sponges and other organisms are very apt to grow round stems of any kind, and when fossilized these would often preserve the cast only of the body around which they grew. A similar question has been raised before with regard to some remarkable forms derived originally from the Chalk, which are known to have been picked up and used as beads in later times.[1]

To sum up. Those who would bring these perforated fossils forward as evidence of the existence of man in the Crag period must show—not only that they are like some objects known to have been the result of human agency—but also that Nature could not or was not at all likely to have produced similar forms.

On the contrary, however, it would appear that most of them are unlike human work, and that some of them were and all may have been produced by well-known natural agents.

IV.—On the Discovery of Reptilian Footprints in Nova Scotia.

By Alfred R. C. Selwyn, F.G.S.,

Director of the Geological Survey of Canada.

The very fine series of fossil footprints which, at my request, Principal Dawson has kindly examined and described in the accompanying note, were discovered last summer, in Nova Scotia, under the following circumstances.

Mr. Scott Barlow, of the Canadian Geological Survey, was at the time engaged in geological explorations in the district of Spring Hill, Cumberland County, where he met Mr. Albert J. Hill, C.E., in charge of works at the bridge over River Philip, on Section viii. of the Intercolonial Railroad, and he informed Mr. Barlow that he had in his possession a slab of sandstone showing small footprints, which he wished to present to the Geological Museum in Montreal. Subsequently, on the 1st September, he informed Mr. Barlow that slabs with large and numerous footprints had been found, and were at the bridge. At the same time Mr. Hill informed Mr. Sandford Fleming, the chief engineer, of this highly interesting discovery, who at once took steps to have all the slabs with footprints preserved, and directed that they should be given to Mr. Barlow, for transmission to the Museum of the Geological Survey.

[1] James Wyatt and Rupert Jones, *Geologist*, vol. v., 1862, pp. 233, 236. See Lyell, Antiquity of Man, p. 119.

The quarry in which they were found is on the land of Mr. Asa Fillimore, about eight miles and a half east of where the thick Coal-seams crop out on the property of the General Mining Association, at Spring Hill, and three-quarters of a mile west of the railroad bridge over River Philip.

The beds, associated with that in which the tracks were found, are of a reddish-brown or chocolate coloured sandstone, from one to five feet thick, overlaid by purple, blue, and red shales. The tracks were at a depth of about twelve feet from the surface, in a thin stratum of dark shale, the dip being S. 10°, W. 42°.

The details of the geological structure of the district have not yet been worked out, and whether the beds containing the footprints are above or below the productive Coal-measures, is at present uncertain.

The accompanying photograph[1] is that alluded to by Dr. Dawson of the slab in Ottawa.

V.—Note on Footprints from the Carboniferous of Nova Scotia, in the Collection of the Geological Survey of Canada.

By J. W. Dawson, LL.D., F.R.S.,

Principal of McGill's College, Montreal.

The principal specimens are several large slabs of brownish sandstone, bearing series of footprints in relief. Of the largest and most distinct series 40 to 50 footprints have been preserved, and are arranged in two rows, about 5½ inches apart. I may confine my attention in the first place to this series, as the most important of the whole.

They were probably produced by a large Labyrinthodont Batrachian walking on a muddy shore, near the edge of the water, and are not very dissimilar from those described by Sir C. Lyell as found by Dr. King in the Carboniferous of Pennsylvania. They also closely resemble, in size and form, the footprints found by Mr. R. Brown, F.G.S., in the coal-field of Sydney, Cape Breton, and described by me in the second edition of "Acadian Geology," p. 358, under the name of *Sauropus Sydnensis,* and still more closely those found by Mr. Jones, F.L.S., at Parrsboro', N.S., and noticed in the same work. With these they may, in the mean time, be included in the provisional genus *Sauropus.*

The dimensions of the footprints are as follows:—

Hind foot, breadth	2·71	inches.
,, ,, length	4·24	,,
Fore foot, breadth	2·63	,,
,, ,, length	2·77	,,
Length of stride	11·53	,,
Average distance between the rows of footprints made by right and left feet	5·48	,,

These measurements correspond very nearly with those of my *Sauropus Sydnensis* above referred to.

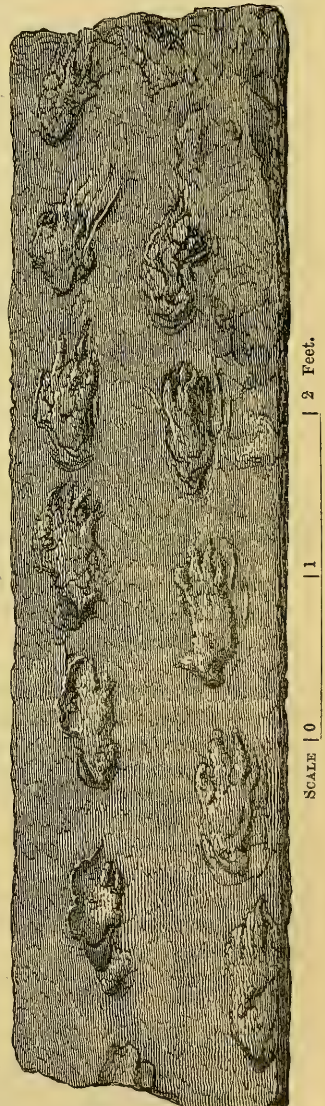
[1] Reproduced as a woodcut on p. 252, one-third less than the original photograph.

The hind foot, it will be observed, is considerably longer than the fore foot, and has a sort of plantigrade appearance; and there are some indications which show that the legs must have been strong and thick. The hind foot shows four well-developed toes, the three outer stronger than the remaining one. There was also a fifth toe, which must have been placed at a higher level than the others, on the outside of the foot. It bore a long claw, which was plunged into the mud at each step, and when the foot was raised made a curved trace on the surface. It probably corresponded to the thumb-like fifth toe of the Labyrinthodont, and to the detached outer toe of the foot-prints figured by Sir C. Lyell. The fore foot is as broad as the hind foot, but much shorter, and shows four strongly-marked toes, with more obscure impressions of a fifth.

All the toes of both feet are broad in front, and seem to have had claws, but not of great length, except in the case of the detached toe of the hind foot above referred to. There is no indication of a membrane connecting the toes.

The prints of the hind and fore feet of each side are in a line, and the distance between the right and left lines, say $5\frac{1}{2}$ inches, indicates a broad body in comparison with the length of the legs. The impression of the hind foot is either a little way behind that of the fore foot, or the impressions are equidistant, indicating a walking gait varying somewhat in the length of the stride.

There are no indications of a tail, and in general the body was carried clear of the ground; but in one place it has been dragged along the surface, leaving longitudinal furrows, probably indicating that the abdomen was clothed with bony scales, as was generally the case in the labyrinthodonts of the Carboniferous. On another slab there seems to have been a soft place where the legs of the animal have sunk deeply into the mud, and it would appear to have been mired, extricating itself with some difficulty, and leaving deep marks of the body and legs.



Sauropus unguifer, Dawson. Carboniferous Sandstone. Nova Scotia.

These footprints must have been made on a subaerial surface, probably left dry by the recession of the tide, and rain must have fallen shortly before the animal passed over it, as indicated by the pitted appearance of the slabs. The trunk of the creature may have been three feet in length. Its tail, if it had such an appendage, must have been short or carried in the air without touching the ground, Its legs were strong, and bore the body well above the surface when walking. The only known Carboniferous batrachian of Nova Scotia which could have made these impressions is *Baphetes planiceps*, Owen, discovered by the author in the coal-field of Pictou. *Eosaurus Acadiensis*, of Marsh, from the Joggins, was a creature of sufficient size, but probably of different structure, and more exclusively aquatic habits.

The principal distinctive character of the present specimens is the peculiar appendage on the hind foot, and from this we may give the provisional name *Sauropus unguifer* to these footprints, until the animal which produced them shall be known to us by its bones.

It is interesting that in three localities in Nova Scotia, and two in Pennsylvania, footprints of this general type and of the same size have been found, indicating the wide diffusion and abundance of these large batrachians in the Carboniferous period in North America, and also that they were animals comparable in size and development of limb with some of their successors in the Mesozoic period.

One of the slabs in the rooms of the Survey shows a number of less distinct footprints of an animal which may have been two-thirds of the size of that above described, though possibly of the same species.

On another slab, and associated with the larger footprints, are some small trifid impressions which seem to indicate the presence of a still smaller animal, with feet of different form from those of the others. These small trifid footprints are not dissimilar from those found by Sir W. E. Logan, at Horton, in 1841, and which were the first indications of reptilian life discovered in the Carboniferous. They are also allied to those subsequently discovered by Dr. Harding at Parboro', and by myself at the Joggins, and referred to in Acadian Geology. These smaller footprints, showing marks of three toes, and in more distinct impressions of four or five, I have conjectured may have been produced by Labyrinthodonts of the type of *Dendrerpeton.*

In addition to the slabs above referred to, there is another in the possession of S. Fleming, Esq., C.E., in Ottawa, of which I have seen a photograph and which is reproduced in the accompanying woodcut. It contains a good series of *Sauropus unguifer*, above described, and shows best the equidistant character referred to of some of the impressions.

VI.—On Changes of Climate during the Glacial Epoch.

By James Geikie, F.R.S.E.

District Surveyor of the Geological Survey of Scotland.

Concluding Paper.[1]

(*Continued from the May Number, p.* 222.)

In a former paper[2] I referred very briefly to the succession of glacial deposits in Switzerland. It was stated that no interglacial beds like those of Scotland and America occur in the Swiss grundmoräne. But, as every geologist is aware, Professor Heer and others have shown that the lignite-beds of the Cantons of Zurich and St. Gall are really of interglacial age, since they not only rest upon but are covered by glacial deposits.[3] There can be but one opinion as to the position in the series occupied by these lignite-beds; they are clearly intermediate in date between the accumulation of the old grundmoräne and the deposition of that "moraine rubbish" which marked the new advance of the glaciers.[4] This being the case, they cannot represent the beds that occur in the "till" of Scotland, but must belong to a later stage. If this correlation be correct, it seems to me that the Swiss beds will serve partly to fill up a great blank in our record, and help us to realize the condition of our country in the long ages that elapsed between the disappearance of the great confluent glaciers and the subsequent period of submergence, which gave rise to the "kames" and "esker-drift." This will appear probable, as I hope to show, after we have taken a glance at the glacial deposits in the north of Italy.

Every glacialist knows that where the Dora Baltea issues from the Val d'Aosta, to enter upon the plains of Piedmont, there occurs a moraine of gigantic proportions. This moraine is not only remarkable for its great size, but for the proof it affords that the mighty glacier to which it owes its origin must have crept over the surface of loose and incoherent deposits of sand and gravel without materially denuding them. The section of the moraine and underlying deposits is given by MM. Martins and Gastaldi[4] as follows:

3. Terrain morainique.
2. Diluvium alpin.
1. Sables Pliocènes marins.

[1] For convenience of reference, the following is the order of appearance of the earlier portions of Mr. James Geikie's paper "On Changes of Climate during the Glacial Epoch."

First Paper—	Geol. Mag.,	Vol.	VIII.,	Decr.	1871,	p. 545.
Second "	"	,,	" IX.,	Jany.	1872,	p. 23.
Third "	"	"	"	" Febry.	"	p. 61.
Fourth "	"	"	"	" March	"	p. 105.
Fifth "	"	"	"	" April	"	p. 164.
Sixth "	"	"	"	" May	"	p. 215.

[2] Geol. Mag., Vol. IX., p. 61.

[3] The mammalian remains associated with the lignite-beds are *Elephas antiquus*, *Rhinoceros Merkii*, Jaeg., *Bos primigenius*, *Cervus elaphus*, and *Ursus spelæus*. See Die Urwelt der Schweiz, p. 497.

[4] Geol. Mag., Vol. IX., p. 62.

[5] Bull. de la Soc. géol. de France, tom. vii., 2me. série, p. 554.

The upper deposit (3) is chiefly noteworthy for its enormous thickness, otherwise it exactly resembles the moraines of the Swiss Alps. The bed 2 also answers precisely to the Alpine diluvium described by Morlot and others. It contains no fossils, and seems to be composed of more or less rounded stones, irregularly stratified. None of the stones are scratched, and no angular blocks occur among them. Towards the upper surface of the deposit, however, erratic blocks begin to appear, and the "diluvium" then assumes the aspect of a moraine profonde. The underlying Sables Pliocènes marins contain a number of fossils, of which the following are said to be characteristic [the notes on the shells have been kindly furnished by my friend Mr. Etheridge]:

Panopœa Faujasii (Menard) occurs in our Coralline Crag and Red Crag, and is living in the seas of Sicily.
Pecten jacobæus; not known fossil in British strata; a Mediterranean shell.
Pecten maximus (Linn); Coralline Crag and Red Crag; Drift; living in British Seas, North Sea, and Mediterranean.
Arca Noe (Mont.) = *A. tetragona* (Poli); Coralline Crag and Red Crag; living in Scandinavian and British Seas, and Mediterranean.
Murex saxatilis; Subappenine shell; not known in Britain; living in Mediterranean.
Murex Brandaris = *M. triacanthus* (Gmelin); Miocene shell; said to be living in Mediterranean.
Nassa conglobata (Broc.); occurs in Red Crag, extremely rare; a Miocene and Subappenine species; not known in our drift; extinct.
Nassa prismatica (Broc.); Coralline Crag and Red Crag; not Glacial nor in any drift; lives in the Mediterranean.
Natica millepunctata (Lamk.) Miocene shell; lives in Mediterranean.
Ranella lævigata (Lamk.) = *R. marginata* (Sow.) Miocene, (?) living. (Much confusion about this shell.)

Resting upon the marine sands which contain the above fossils, occurs here and there an ancient alluvium, which is believed by Martins and Gastaldi to be of older date than the alpine diluvium. This deposit has yielded remains of the Mastodon, the Rhinoceros, the Hippopotamus, etc., along with shells of such genera as *Clausilia, Paludina,* and *Helix.* In the paper to which I am indebted for these details, Martins and Gastaldi correlate this section with that at Dürnten, and are clearly of opinion that the Italian "alluvium with bones" is the equivalent of the slate-coal or lignite of Switzerland. But at the time their paper was written, the interglacial character of the Dürnten beds had not been ascertained. It is, therefore, possible that their opinion on this point may have undergone some change [1] since that discovery was announced; for, according to them, the marine sand and freshwater alluvium of the plains of Piedmont are Pliocene, and therefore preglacial. Many considerations, however, lead me to believe that the correlation of the Italian and Swiss deposits, which Martins and Gastaldi have made, need not be abandoned, notwithstanding that the Dürnten beds have since proved to be of interglacial age.

It will readily be admitted that the vast changes of climate which are indicated by the interglacial beds and associated deposits of

[1] In a recent memoir Gastaldi takes no notice of the Dürnten beds, and continues to describe the Italian deposits as belonging to the Pliocene. [See *Studii sulle Alpi Occidentali; Mem. del R. Comit. Geol. d'Ital.*, vol. i., 1871.]

Dürnten could not be due to mere local causes affecting Switzerland alone—they must have left their mark over a wide area in Europe. It is therefore not unreasonable to expect that among the glacial deposits of Italy we ought to find some traces of former oscillations of climate. As far as I am aware, however, no such traces have yet been recognized. All that has been asserted in regard to the old Italian glaciers is simply this—that they once deployed upon the plains of Piedmont, and finally retired, leaving behind them, as marks of their ancient extent, the gigantic moraines of the Dora Baltea, the Dora Riparia, and those in the neighbourhood of Arona.

It will be remembered that one of the strongest objections to Prof. Ramsay's theory of the origin of lake-basins by glacial erosion, was the fact that the vast glaciers of Italy had actually crept upon the plains of Piedmont, without excavating any great cavity in the soft Pliocene sands.[1] I have always felt that this objection would have some force, if it could be shown that the so-called "Pliocene" beds which underlie the great moraines are really of preglacial age. But this is just the point which has not yet been proved. The mammalian remains in the old alluvium certainly do not prove it, neither do the shells which occur in the underlying marine sands. Of the nine species of mollusca mentioned by Martins and Gastaldi as characteristic, seven are still living in the adjoining seas, one is doubtful, and only one is said to be extinct. There is nothing, therefore, in the fossil-evidence to show that these beds are of preglacial age: as far as that goes, they might quite well belong to interglacial or still more recent times.

If interglacial beds do not now occur in the north of Italy, it is not because they never existed; their absence can only be accounted for by denudation. During that long interglacial period in Switzerland, when the colossal glaciers had shrunk back to the deep Alpine valleys, and oaks and pines clustered along the borders of the Swiss lakes, the vast glaciers of the Italian Alps must likewise have retired, and vegetation must then have followed their retreating steps towards the mountain fastnesses. When the cold returned, and the glaciers of Switzerland once more ploughed their way outwards, until they reached a point far beyond where the lignite-beds are now found, it is equally certain that this ice would creep down the Italian valleys, and might well deploy upon the plains of Piedmont, here scooping out, and there covering up with debris the aqueous deposits which had gathered in its absence. All that the last great advance of the glaciers could do would be to deepen rock-basins which had been hollowed out in the preceding cold periods of the glacial epoch, and slightly to erode and smooth valleys whose origin dates back to times incalculably more remote than even the dawn of the glacial epoch. If during the last interglacial period, when the Dürnten beds were being formed, all the great lake-basins of the Alps had been silted up, it is highly improbable that these hollows would have been again cleared out by the last extension of the glaciers. To have allowed such a silting-up by streams and

[1] Antiquity of Man, p. 313.

rivers, however, the latest interglacial period must have been very prolonged indeed; of much greater duration, in fact, than we have any grounds for believing it to have been. But what could not be effected by streams and rivers, might yet be accomplished by the sea. If while the last interglacial period endured, and the elephant and its congeners wandered along the shores of Zurich and the Lake of Constance, the north of Italy happened to be submerged to a depth of 800 feet or thereby below its present level, then it is conceivable that some of the great rock-basins at the mouths of the Alpine valleys might become filled up with marine deposits. Now this is just what I would infer did take place in the early stages of the last interglacial period, and the so-called "Pliocene sands" are the deposits which I am inclined to believe were then laid down. While the genial climate which marked the deposition of these sands continued to prevail, it would seem that the movement of subsidence which had brought the base of the Alps within reach of the waves was reversed, and the land once more appeared. Rivers then flowed over what had recently formed the bed of the sea, and deposited those alluvia in which the remains of Mastodon, Hippopotamus, etc., are entombed. As this mild period drew to a close, snow and ice again thickened in the valleys, and torrents in summer-time overspread the plains of Piedmont with great deposits of gravel—the Alpine diluvium of Italian geologists. When the glaciers once more issued from their deep valleys, they would be unable to clear away the immense deposits of diluvium and marine sand which had collected during the previous mild interglacial period. And thus it seems to me not improbable that large and deep rock-basins do really exist below the marine sands of Piedmont at those points where the valleys of the Dora Baltea and the Dora Riparia open upon the great plains.

In support of this opinion, it may be remarked that along the frontiers of the Alps, between Arona and Rivoli, there appears to be an entire absence of the grundmoräne, which in Switzerland extends to such a distance beyond the limits reached by the newer moraines that overlie the lignites.[1] It is hardly conceivable that, during the accumulation of the Swiss grundmoräne, the glaciers of Italy never extended further south than the ground now occupied by the great moraines. Mere difference of latitude does not enable us to get over this difficulty. We may readily admit that the Italian glaciers would be arrested in their downward course sooner than those of Switzerland; yet the vast extent of the Swiss grundmoräne indicates a former intensity of cold, which must needs have given rise to glaciers in Italy of even greater magnitude than those which piled up the gigantic moraines of Ivrea. If, however, it be possible to admit the interglacial age of the marine sands, etc., of Piedmont, then all our difficulties vanish, and the absence of lake-basins and older glacial deposits is at once accounted for.[2]

[1] Unless, indeed, some of those large erratics which are found upon the hills above Turin be the representatives of the older Swiss moraines. Gastaldi, however, believes them to be of Miocene age.

[2] When, some time ago, I communicated to my friend, Prof. Ramsay, a rough out-

In a previous paper[1] I remarked that we have no certain record of what transpired in Britain between the final disappearance of the confluent glaciers and the deposition of the esker-drift,—all that we can safely assert is, that "the ice had in large measure melted away from the land before submergence ensued." We are quite sure that a land-surface existed in the British area after the disappearance of the great ice-sheets, and before the accumulation of the kames, although whether our country was continental or not, there is no evidence in Britain to show. But that such may have been the case would appear not improbable from the following considerations.

If we compare the deposits accumulated during the last interglacial period in Britain, Switzerland, and, as I have suggested, in Italy, we shall find that movements of elevation and depression have affected the northern and southern regions of Europe alternately. This will be seen at a glance when the separate sections are placed side by side. The series are arranged in descending order :—

Britain.	*Switzerland.*	*Italy.*
3. Moraines, brick-clays, and erratics : *Land and Sea.*	3. Moraines : *Land.*	3. Moraines : *Land.*
[Cold Conditions.]	[Cold Conditions.]	[Cold Conditions.]
2. { *b* Kames, sand and gravel : *Sea.* *a* ? River deposits, etc. *Land.*	2. Lignite beds : *Land.*	2. { *b* Old alluvia : *Land.* *a* Sand, etc. *Sea.*
[Mild Conditions.]	[Mild Conditions.]	[Mild Conditions.]
1. Glacial deposits.	1. Glacial deposits.	1. Probably glacial deposits.

Many facts seem to show that any considerable subsidence of the earth's crust in one region will be accompanied by a corresponding elevation in some other area; or, to put it the other way, elevation in one place will be accompanied by subsidence in another. If this view be not unreasonable, it is, to say the least, quite possible that while the north of Italy was being slowly depressed, the British area was being as gradually upheaved. It is true we do not know at what elevation Italy stood above the sea before the depression began, nor can we be quite certain as to the line eventually reached by the waves along the flanks of the Alps. But the subsidence probably did not greatly exceed 800 feet or thereby below the present level of the Mediterranean; and we shall perhaps not be deemed extravagant if we assume that before the land began to sink it was at least not less extensive than it is now. Returning to Britain—it would not be difficult to show that even after the deposition of our kames had commenced Scotland stood at a level relative to the

line of these suggestions, I was pleased to hear from him that he had long been of opinion that the plain upon which Aosta stands is an old rock-basin filled up with alluvium, and that there are others of the same kind between that and Ivrea. "These are common," he says, "in many of the great Alpine valleys, and in Cumberland they are very frequent." [Similar phenomena, I may add, occur in Scotland.] There is no reason, Prof. Ramsay thinks, why the old ossiferous alluvium described by Martins and Gastaldi, should be called *Pliocene*, and perhaps as little for referring to that period the marine sands with shells. These beds might be of the same age as the Cromer Forest bed, or even much younger.

[1] Geol. Mag., Vol. IX., p. 23.

present coast-line not much below where it stands now. But to adduce proof of this would lead me into too much detail, and I shall therefore take the liberty of assuming that before the process of subsidence commenced in Italy, the shores of that country and of Britain occupied very much the same position as at present. It is evident, on the hypothesis referred to above, that long before the interglacial submergence in Italy (so-called pliocene beds) could reach its climax, Britain would become continental. An elevation of only 120 feet or thereby would be sufficient to effect a junction; and even if the upheaval in Britain reached but half the extent that the subsidence ultimately attained in Italy, the sea must have well-nigh vanished from the bed of the German Ocean and the English Channel at a time when the waves were washing the base of the Italian Alps. Such a continental condition would probably endure for a lengthy period, to be measured by the time required for the subsidence of Piedmont, the accumulation of the so-called "Pliocene sands," and the partial re-elevation of the land. For if, during the subsidence of Piedmont, Britain became continental before that downward movement was completed, our country would continue in the same condition for some time even after the re-elevation of Italy had begun. But as Italy mounted higher and higher, the sea would gradually steal in between Britain and the Continent until complete insulation was brought about. Thereafter, the subsidence in Britain continued until the Welsh mountains were laved at a height above the present coast-line of not less than 1400 or even 2000 feet. With such excessive depression in the north of Europe—a depression that brought the sea over a large part of Scandinavia, Russia, Germany, Denmark and Holland—it may be inferred that the elevation in the south of Europe raised far above the sea-level grounds which now lie drowned in the Mediterranean.[1]

In the early stages of this period of elevations and depressions the climate would appear to have been mild and genial all over Europe; indeed, it is very doubtful whether any glaciers existed in Britain at this time. For the climate of the last interglacial period may fairly be inferred to have been as genial as the succeeding glacial period was cold. It was under such conditions that the Elephant, the Rhinoceros and other extinct mammalia inhabited Switzerland. Then, too, Man and the great pachyderms (Rhinoceros, Hippopotamus, etc.) may have crossed into Britain—but not for the first time. Some portion of the English river-gravels and cave-deposits I would therefore refer to this period. Of course I am aware that no traces of this old land-surface have yet been detected underneath the kames of Scotland. But as the very presence of these deposits presupposes great denudation, the absence of any traces of a land-surface is hardly to be wondered at. In this connexion, however, I would refer to the peat (with palæolithic implements and bones of the

[1] If the upheaval in the south of Europe at all equalled the depression in the north, it can hardly be doubted that there would be land communication between Africa and Europe—the soundings between Sicily and Cape Bon indicating the presence of a submarine ridge within less than 100 fathoms from the surface.

cave-bear), which Prof. Nilsson describes as underlying the Jära-wall—a great ridge of sea-gravel extending "along the coast of the Baltic from Ystad to the part between Trelleborg and Falsterbo." If this ridge be an åsar (as from the description may be inferred), and should it prove to belong to the great åsar series, this would *demonstrate* that man had inhabited Sweden before the last great submergence and period of floating-ice.

Before leaving the subject of the superficial deposits of Italy, it may be remarked that in the marl-beds and morainic turbaries of Piedmont, the most ancient relics of man yet detected belong to the neolithic and bronze periods—the Italian *palafitte* answering precisely to the Swiss *pfahlbauten.* The animal-remains associated with the palafitte, are the dog, pig, horse, ox, goat, sheep, stag, roebuck, boar, bear (*Ursus arctos*), etc. In none of the peat-mosses, alluvia, or marl-beds, which are clearly of later date than the moraines, have any of the old pachyderms occurred; these have only been met with hitherto in caves and in deposits of older date than the moraines and the "Alpine Diluvium" upon which these latter rest.[1]

Similarly, as regards Switzerland, the alluvium that fills up depressions in the morainic deposits, or otherwise occupies positions which show it to be of postglacial age (that is, of later date than the last great advance of the glaciers), contains none of the "Quaternary" mammalia, but an assemblage of fossils similar to that of the marl-beds and morainic turbaries of Italy. The Dürnten beds, with elephant and rhinoceros, occupy, beyond question, an interglacial position—they rest upon and are clearly covered by glacial deposits.

In Scotland and Scandinavia similar phenomena recur. None of the pachyderms are found in any postglacial bed; but underneath the till, and in interglacial beds, in the former country, we get the mammoth, the reindeer, the urus, the horse, and the Irish deer; and in the latter country we find bones of the cave-bear along with palæolithic implements imbedded below deposits which are probably the equivalents of our kames.

The marl-beds, alluvia, and peat-mosses of Northern Europe, like the equivalent deposits which overlie the later glacial accumulations of Italy and Switzerland, have only yielded relics of the neolithic, bronze, and iron periods.

I would also remind the geologist of the very remarkable distribution of the Quaternary mammalia in high latitudes of Asia and North America. All the great rivers of Northern Asia, from the borders of Europe to Behring's Straits, appear to flow through alluvial deposits, which are often literally packed with the remains of mammoth, Siberian rhinoceros, etc. Similar fossils are met with, but not so abundantly, on the banks of several rivers in Alaska. But in the northern latitudes east of the Rocky Mountains no such mammalian remains have been detected. According to Sir J. Richardson, "none have hitherto been found in Rupert's Land, though the annual waste of the banks of the large rivers and the frequent land-slips would have revealed them to the natives or fur

[1] Gastaldi, Lake Habitations and Prehistoric Remains in Italy.

traders had they existed even in small numbers. They are rare, also, or altogether wanting, in Canada; but in the valley of the Mississippi the bone-licks are well known as most extensive, and furnishing the remains of a different series of extinct quadrupeds." [1] In Michigan, which is fairly within the glaciated region of North America, mammalian remains are only met with in what appear to be interglacial deposits: at all events, the deposits referred to overlie and are covered by glacial accumulations. The great "bone-licks," to which Sir J. Richardson alludes occur beyond the southern limits of the "Northern Drift."

Thus it will hardly fail to strike one as remarkable, that remains of the extinct mammalia are either altogether absent from, or very sparingly present in, regions which give evidence of having been subjected to more or less intense glaciation, or are covered by deep accumulations of the later glacial drifts. In Britain, Italy, and Switzerland alike the old ossiferous alluvia, when traced from the low grounds to the mountains, disappear as soon as the moraines and "alpine diluvium" are reached. Nowhere in morainic turbaries or alluvium which can be demonstrated to be of postglacial age do any traces of the extinct pachyderms appear. But these, when they do occur in glaciated or drift-covered regions, are invariably embedded in infraglacial or interglacial deposits. It is so in Scotland, and (if the Jära-wall be one of the åsar) in Scandinavia also. The same rule seems to hold good with respect to Asia and North America. The great plains of Siberia never could have nourished glaciers. We cannot conceive that even during the most intense cold of the glacial epoch, conditions similar to those which characterized Scandinavia and Scotland could have existed in Northern Siberia: the absence of high-grounds and the comparative dryness of the climate must have prevented any accumulation of glacier-ice. Nor can I learn that marine deposits, similar to our boulder-clays and esker-drift, cover any portion of Northern Asia. If cones and mounds of sand and large erratics,[2] like those of North America, occurred in Siberia, travellers would hardly have failed to mention them. But all this is changed when we pass into the corresponding latitudes of North America east of the Rocky Mountains. There the observer encounters the marks of glaciation everywhere—everywhere, too, are great deposits of clay and boulders, mounds and ridges of sand and gravel, and huge erratics. And all over this wide area, down to the borders of the United States, the extinct mammalia never appear in any postglacial deposits. In the neighbourhood of the great lakes they occur in freshwater clays, along with abundant vegetable remains, and these clays are overlaid by glacial beds. It is only when the southern limits of the "Northern Drift" are approached, that the extinct mammalia begin to be found

[1] Journal of a Boat Voyage through Rupert's Land, vol. ii., p. 210.

[2] Middendorf told Sir C. Lyell that he had observed erratic blocks in strata of clay and sand at about fifteen feet above the sea in lat. 75° 15′ N., near the river Taimyr. (Principles, vol. i., p. 185, tenth edit.) But these erratics were probably carried down by river-ice.

QUATERNARY DEPOSITS OF THE BRITISH ISLANDS, WITH SOME OF THEIR EQUIVALENTS IN OTHER COUNTRIES.

		DEPOSITS.	FOSSILS.	PHYSICAL CONDITIONS.	FOREIGN EQUIVALENTS.
	Recent Period.	1. Alluvium, Peat, Raised Beaches.	1. Sub-fossils.	1. Partial re-elevation, the Present.	1. Alluvium, loam, marl, peat, bog-iron ore, calcareous tufa, &c.
	Post-Glacial Period	2. Peat, buried forests, river and cave deposits, in part.	2. Relics of Man; recent and extinct, or no longer indigenous mammalia, *Reindeer*, *Megaceros Hibernicus*, *Bos primigenius*, *B. longifrons*.	2. Continental Condition of British Islands followed by partial submergence; seasons towards close of this period more marked than at present; in the earlier stages climate more severe than now; Neolithic man; and passage to bronze and iron periods.	2. Denmark—Peat and buried trees in part. Kjokkenmöddings. Switzerland—Pfahlbauten. France, Belgium, &c.—River and Cave deposits in part, with reindeer, aurochs, &c. Italy—Palafitte, &c. Neolithic man, passage from stone to bronze and iron periods.
		3. Raised Beaches, &c.	3. Littoral shells, &c.	3. Elevation of the land; climate cold-temperate.	3. Scandinavia—Raised Beaches.
The Glacial Epoch.	Last Glacial Period	4. Valley Moraines and river gravels (diluvium), river gravels in South of England.	4. Arctic Mammalia, Mammoth, Siberian Rhinoceros, &c.	4. Local Glaciers in Mountain Valleys; land probably rising.	4. Germany—Terminal Moraines in Black Forest and the Vosges; loess of the Rhine and Neckar in part, with *Elephas primigenius*, *Rhinoceros tichorinus*, &c. France and Belgium—River and cave-deposits in part.
		5. Sand and Brick Clay.	5. Boreal and Arctic Shells.	5. Arctic Climate; land of less extent than now, but gradually rising.	5. Scandinavia—Sand and Clay, with Arctic shells. Switzerland—Moraines overlying older glacial and inter-glacial deposits; alpine diluvium, &c. France, Belgium, &c.—River and Cave deposits with Arctic Mammalia; Mammoth, Siberian Rhinoceros, &c.
		6. Erratic Blocks and earthy debris	6. No fossils.	6. Period of floating ice; land deeply submerged, but rising.	6. Scandinavia, Denmark, and Northern Europe generally—Erratics. Switzerland—Great extension of Glaciers; terminal Moraines. Italy—Moraines of Rivoli, Ivrea, &c. France and Southern Europe—River and Cave deposits, with Arctic Mammalia and palæolithic implements.
		7. High Level Beaches and Marine Drift.	7. Shells indicating a somewhat cold sea.	7. Submergence of the land to a depth in Wales and Scotland of about 2000 ft.; land south of the Thames not submerged (?); climate passing from temp. to Arctic; land rising.	7. Scandinavia—High-level Marine Drifts. Switzerland and Italy—Advance of Glaciers; older Alpine diluvium. France and Southern Europe—River and Cave deposits

The Glacial Epoch.	Last Inter-Glacial Period ...	8. Kames, Eskers, &c.	8. Shells same as species living in British seas.	8. Land sinking; climate temperate.	8. Scandinavia and Northern Europe—Åsar, and plateaux of Marine Gravel and Sand. France—Diluvium of plateaux. Germany—Gravel of Vosges and Black Forest. Switzerland—Dürnten beds in part.
		9. Cave Deposits; river gravels, &c. in part.	9. Palæolithic implements; extinct and no longer indigenous mammalia; hippopotamus, rhinoceros, elephant, &c.; mammoth, Siberian rhinoceros, &c.	9. Britain at first insular with cold climate; next continental with climate changing from cold to temperate and genial, and again to temperate; in early stages of continental conditions the Arctic Mammalia invade Britain, subsequently these disappear and are succeeded by the hippopotamus, &c.; afterwards submergence ensues and insulation perhaps effected before the climate again becomes suited to Arctic Mammalia.	9. Scandinavia—Peat, with palæolithic implements and cave-bear below Jära-wall. (?) Switzerland—Dürnten beds with *Elephas antiquus*, *Rhinoceros Merkii*, &c. Italy—Ossiferous Alluvium of Piedmont; Marine Sands (so-called Pliocene) of Piedmont. Europe generally—Cave and River deposits, with palæolithic implements, and extinct or no longer indigenous mammalia.
	Great Cycle of Glacial and Inter-Glacial Periods ...	10. Morainic rubbish and "Diluvium."	10. No fossils.	10. Arctic Conditions passing away; Local Glaciers.	10. Switzerland—Moraine rubbish. Formation of loess in river valleys generally = fine glacial silt.
		11. Boulder-earth and clay of maritime districts. [in inland parts, Till with no fossils.]	11. Arctic Shells in part.	11. Arctic Climate; Mountainous parts of Britain covered with snow and ice. Glaciers cease to be confluent.	11. Switzerland—Grundmoräne in part. Scandinavia—Stony clay in part.
		12. Till and Boulder-clay with intercalated and subjacent beds of silt, sand, clay, gravel, &c.; cave deposits; river gravels, &c.	12. Arctic Shells in part; oak, birch, pine, hazel, alder, willow, &c.; extinct and no longer indigenous mammalia, both of Arctic and Southern forms; Palæolithic implements.	12. Intense Glacial conditions with great confluent glaciers; intermediate mild and warm periods; Arctic and Southern Mammalia visit Britain alternately, according as climatal conditions become suited to their needs.	12. Scandinavia—Upper and lower Stony clay, with underlying gravel and sand. Switzerland—Grundmoräne. Europe generally—River and Cave deposits, with palæolithic implements and Arctic and Southern Mammalia.
	Pre-Glacial Period ...	13. Norwich Crag.	13. *Elephas*, *Mastodon*, &c.; some northern species of shells.	13. Indications of approaching cold.	13. ?

in any numbers at the very surface; and their remains occur in greatest profusion in the regions which have not been reached by the drift.

This anomalous distribution of the extinct mammalia appears inexplicable on the assumption that the ossiferous beds are all of postglacial age; but if they belong for the most part to interglacial times, the mode of their occurrence is precisely what might have been expected. It seems indeed impossible to resist the conclusion that at the time the mammalia frequented the lower latitudes of Europe (where their remains occur so abundantly in river-gravels and cave-deposits), and while mammoths, horses, buffaloes, and oxen roamed over northern Siberia—Scotland, Ireland, Denmark, Scandinavia and other regions of Northern Europe also supported an abundant mammalian fauna, and that the mastodon and its congeners likewise occupied what are now the wooded regions and barrens of North America. And the remains of these creatures seldom or never occur in the regions rèferred to, because either the deposits which once contained them have been obliterated by the action of ice, or are covered up and concealed by drift accumulations.

Hitherto no reference has been made in these papers to Mr. Croll's theory of the physical cause of changes of climate during geological epochs. That theory for the first time rendered possible the reconciliation of apparently contradictory facts. Phenomena which had refused to be explained by any number of ingenious hypotheses suddenly seemed to yield their secret, and the great "Age of Ice" appeared all at once in a new light. The results of recent research in this and other countries tend more and more to show that the indirect influence of excentricity of the earth's orbit is the prime cause of cosmical changes of climate. It was in 1864 that Mr. Croll's first paper upon this subject appeared. At that time very little was known about interglacial periods. Ramsay had already shown that as regards Britain there had been two periods of great extension of glaciers separated by an intervening age of submergence and floating-ice. Morlot had also pointed out that the morainic deposits of Switzerland gave evidence of the former existence of two ice periods, and his results had subsequently been remarkably confirmed by Professor Heer, and others.[1] But these later observations were certainly not generally known in Britain at the time when the theory I refer to was published. It was, however, a familiar fact that interglacial beds occurred in the till of Scotland, and from the appearance of these deposits my brother had inferred that the great ice-sheet occasionally melted away so far as to uncover

[1] I learn from Mr. A. E. Jörnebohm, of the Geological Survey of Sweden, that in that country there are two Tills, both of which he considers to be true *moraines de fond*. He says that "the line of demarcation between them is generally very sharp, and in some places the lower till has evidently been partly broken up, and denuded before the upper till was deposited." "These facts," he continues, "seem to point out that during the glacial period there was a great interval of comparatively mild climate, when the ice retreated to the mountain regions; the land, however, was not submerged. Freshwater and superficial deposits that gathered during that interval may have been completely destroyed by the returning ice."

some portion of the low grounds of Scotland. But certainly no English geologist had up to the appearance of Mr. Croll's first paper in the *Philosophical Magazine* ventured to affirm that the climate of these interglacial periods in this country could be other than cold or sub-arctic. Indeed, the facts then known did not warrant any such conclusion. But the publication of this ingenious theory tended to revolutionize all our previous conceptions on the subject; for, if there was any truth in the hypothesis at all, then the records of mild and even genial interglacial periods might certainly be expected to occur. The former existence of such periods followed no less surely from theory than did that of cold and arctic conditions. Mr. Croll himself had referred to the intermingling of arctic and southern mammalia in the valley-gravels as in favour of his hypothesis, an explanation of the facts which, Sir J. Lubbock remarks, at once gets rid of what has always hitherto been considered a difficulty. By many English geologists, however, the valley-gravels with extinct mammalia were, and still are, believed to be of postglacial age. Others again, as Mr. Godwin-Austen, are of opinion that these gravels in the south of England are the equivalents of the glacial deposits in the north. But as far as I am aware, no geologist has yet attempted to correlate the river-gravels with undoubted interglacial deposits. I was in hope that ere long some one well acquainted with all that pertains to the superficial deposits of England would address himself to this task; for it seems to me that a far deeper significance attaches to the interglacial deposits of Scotland, Switzerland, and America than has yet been recognized, otherwise their bearing on the phenomena of the English drifts could hardly fail to have attracted more attention. That many of the views entertained in these papers have already occurred to fellow-workers in other fields is extremely likely; some of the conclusions indeed appear too obvious to have escaped attention. Others again are novel and opposed to prevailing ideas, and these I should like to have discussed at greater length, but I have already covered too many pages of the Magazine. I hope, however, to enter more fully into the whole subject of glacial and interglacial climates in another place. It would extend this paper (already long enough) beyond due limits were I to attempt any summary of the conclusions arrived at in this and preceding papers: the accompanying table (pp. 262, 263), however, will show the arrangement of the Quaternary deposits which has been suggested.

VII.—Middle Gravels (?), Ireland.

By G. H. Kinahan, M.R.I.A., etc.

In a paper on a comparison of the drift of Ireland with that of Lancashire, the author Prof. Hull states, that he recognized the equivalents of the English beds in the drift cliffs at Killiney, Co. Dublin,[1] and in the Geol. Mag. for March, 1872, Mr. J. Geikie has quoted Prof. Hull: I therefore request leave to say a few words about the gravels of Ireland, more especially as Mr. Geikie

[1] Geol. Mag., Vol. VIII., p. 294.

seems to have mistaken my notes on the Irish drift, making it appear that I believe the "Esker Gravels" contain similar marine fossils to those characterizing the "Manure Gravel" of the Co. Wexford. Such a statement, however, would not bear investigation. Only in three places have undoubted fossils been found in the "Esker gravel." *First,* shells are recorded from gravel near Roscrea by Prof. Oldham; these, however, must be very rare, as, although carefully looked for, they have not since been remarked. *Second,* shells are stated to have been found by Mr. Mallet in "Esker gravel." Where this statement is recorded I am not sure, therefore I can give no particulars. *Third,* I found a bit of *one* shell, a bivalve, in the "Esker gravel," at Maryboro', Queen Co.

From such evidence no comparison can be drawn. Furthermore, as pointed out by Prof. Harkness, chalk-flints are characteristic of the "Manure gravel," while none are recorded from the Esker gravel; not that I would assert that a gravel without flints in one place may not be the representation of a gravel with flints in another, as stated by me at the Edinburgh Meeting of the British Association (1871). In the east parts of the Cos. Wicklow and Wexford there are gravels with flints; while to the westward, in the valley of the Barrow, the "Esker gravel" seems to be without them, therefore Mr. Geikie's suggestion, that the Manure gravels and the Esker gravel contain "a similar assemblage of marine shells," must be received with a great deal of caution, as eventually it may be proved to be erroneous.

I believe the relations between these different gravels are very obscure, and as yet quite unknown. The Esker gravels of the central plain (or upper esker gravels) are between heights of 200 and 350 feet. The Esker gravels of the valley of Lough Corrib (or lower esker gravels) are at a less height, and appear to be of the same age as the raised sea-beaches in Cos. Cork and Kerry, the lower raised beach in Co. Limerick, and the lower gravel terraces in Cos. Clare, Galway, and Mayo. In all the western portion of Ireland there is a limit to the variation in the heights of these gravels, but the Shell or Manure gravels seem to have uncertain limits. On the east coast, from the sea-level upwards, to a height of at least 1,200 feet, these gravels have been proved by the Rev. M. H. Close, and they have been traced by different observers northward and north-westward to Blacksod Bay; while Harkness has followed them southward and south-westward to Roaring-water Bay; their greatest development and maximum height apparently being to the east. At Blacksod Bay they were found at a height of 250 feet; at Roaring-water Bay they are close to the present sea-level, and at a similar height, farther north, in the Cos. Clare and Galway, accumulations of gravel occur, sometimes containing shells, but in them chalk-flints were not observed. What to me, however, appears most inexplicable is, that at about a similar height (1,200 ft.) to where Mr. Close found the fossiliferous gravel in the east, there are in the west, numerous terraces and cooms, believed by me to mark an ancient sea-margin,[1] yet the

[1] The Rev. M. H. Close has different views with regard to the origin of these cooms.

gravels do not occur associated with them, and no trace of the high level shell-gravel has hitherto been discovered.

When I wrote on the Eskers of the central plain of Ireland in the paper[1] referred to by Mr. Geikie, my conclusions were nearly altogether drawn from the phenomena presented by the Eskers, and from them I concluded that the margin of the Esker-sea in western Ireland must have been about 250 or 350 feet higher than at present. Since then I have had opportunities of examining the valleys in the hill counties of Cork, Kerry, Limerick, Clare, Galway, and Mayo, and am not surprised to find that, in these different counties, there are traces of a well-marked ancient sea-margin, about 300 or 350 feet above the Ordnance datum line, proving that what I suggested, from the facts given by the eskers, is borne out by quite independent data. Some of the facts relating to the upper and lower gravel terraces have already been published in the Memoirs of the Irish Branch of the Geological Survey, while those of Yarconnaught and South Mayo will, I hope, shortly be described by my fellow-workers.

Now to return to the supposed "middle gravels" of the east coast. If the section between Killiney Hill and the drift cliff immediately south of the mouth of the Shanganagh River is examined, it will in part be like Prof. Hull's sketch section; that gentleman's section, however, toward the south is incorrect, as his "middle gravels" do not occur in a basin, but continue to the Bray River, lying on a denuded surface of the Boulder-clay drift, the latter in places disappearing below the present sea-level, these depressions being due to faults in the drift, a well-marked step fault being exposed at the south end of the section, at the site of the Bray river Martello tower. In this section the accumulation over the Boulder-clay drift shows that the "Shell gravels" may graduate into clayey gravels (in places somewhat like a Boulder-clay drift), or even into a brick clay, while in places beds of gravels occur in the underlying Boulder-clay; these beds, however, not being separate members of the group, but rather integrants of the whole. Prof. Harkness agrees with me that there is no deposit between Killiney Hill and Bray River that could possibly be called an Upper Boulder-clay drift. This observer believes in an Upper Boulder-clay drift, but in other localities. Of the Upper Boulder-clay drift he states that it is seen in the railway cutting between Brayhead and Greystones, but is in perfection at Castle Ellis, Co. Wexford; the latter locality, quoting from his letter, "affords the clue to all the shelly sands and gravels of Ireland." To me it appears that here or elsewhere a Boulder-clay drift bed may lie on "shelly sands and gravels," and yet not prove that there are three divisions in the drift, for if a large glacier ends in the sea (such as the Humboldt glacier in Smith's sound), the place must be marked by variations in the deposits, a shelly sand and gravel forming during a warm year, or series of years, while subsequently if a cold year or years follow there would be a Boulder-clay accumulation, thus in successive years forming

[1] "Notes on some of the Drift in Ireland," by G. H. Kinahan, Dublin Quart. Journ. of Science, vol. vi., p. 249.

alternations of the different drifts, but only in certain spots, and not over large tracts. Such alternations are well exemplified in the drift cliff bounding the plain of Limerick on the west; the succeeding hot and cold years being registered by gravels and Boulder-clays, (not necessarily separate members but rather parts of a whole) all merging one into the other; yet I believe an ardent theorist could conveniently prove that instead of there being one Boulder-clay period in that district, there were six or eight, with about an equal number of periods of "middle gravel."

In conclusion, I wish to point out, as it seems not to be generally known, that the "Esker gravels" of the central plain of Ireland lie on the *Boulder-clay-drift*, in which the principal blocks and fragments are more or less rounded, and usually of limestone, while in the vicinity of the hills and mountain groups the eskers (*Anglicè* ridges) continue on to the *Boulder-drift*. The latter drift is always more or less local in character, contains more or less angular and subangular blocks and fragments, always overlies the Boulder-clay drift, and in places merges into the *moraine drift* found in the mountain valleys.

VIII.—On a Worked Flint from the Brick-earth of Crayford, Kent.

By the Rev. O. Fisher, F.G.S.

During a visit to Crayford in April, under the guidance of my friend Mr. Dawkins, I obtained a worked flint from Slades Green Pit. The discovery seems worth recording, on account of the presumed early age of the deposit in which it occurred. Mr. Evans has kindly looked at the specimen, and considers it decidedly to have been worked, so that there is no room for doubt upon that head. I picked the implement out of a band of rounded flint gravel, lying beneath the sandy stratum which contains abundance of shells, and among them the *Corbicula* (or *Cyrena*) *fluminalis* and *Unio litoralis*, together with many mammalian remains. The section was roughly as follows:

North East end of Slades Green Pit.	ft.	in.
Trail of Clay (about)	6	0
Sandy brick-earth with freshwater shells	5	0
Pebbly band *with worked flint*	0	5
Gravelly brick-earth	6	0

It appears probable that the layer of gravel in which the worked flint occurred is on the horizon of No. 2 in Mr. Dawkins' section, fig. 3. (see Quart. Journ. Geol. Soc., Lond. 1867, vol. xxiii., p. 96.)

As far as I know, this is the first instance of obtaining evidence of the existence of man in this country in association with *Corbicula* (or *Cyrena*) *fluminalis*. Mr. Prestwich, however, records having found that shell in the implement-bearing gravel of Menchecourt.[1] And I think this is the first time of finding anywhere a chipped flint in association with *Unio litoralis*.

Rhinoceros megarhinus found here, though not commonly met with in implement-bearing[2] gravels, is mentioned as occurring at Bedford.

[1] Phil. Trans., part. ii., 1864, p. 282. [2] *Ibid*, p. 284.

The absence of Reindeer at Crayford is an unusual circumstance iu connexion with the presence of worked flints.[1]

I noticed that the Brick-earth in Slades Green Pit is deposited against an old talus of chalk, which had previously fallen from a cliff which formed the side of the river-valley at that place. This talus may be seen by going through the tunnel on the south side of the pit, and examining the chalk-pit into which it opens. The chalk next the tunnel consists of fallen rubble, and, although the junction is not exposed, it is clear that the brick-earth must abut upon it. I should argue from this, that the river or estuary-waters remained for some while at a considerably lower level than that which they afterwards attained, when the flood-waters deposited the brick-earth. Such a rise of the water-level seems to require subsidence to account for it, and that the subsidence brought the Thames valley a few miles lower down, under strong tidal action, appears to be shown by the cross-bedded sands of Gray's Thurrock. Whatever it may have been at some periods of its history, the Thames could scarcely have been at that time a tributary of the Rhine, but must have possessed an estuary of its own as at present, and probably the tide came even higher up then than it does now.

Subsidence, at a period which was in all probability nearly the same, is evidenced by the estuarine beds which overlie the mammalian deposit at Clacton, in Essex.[2]

Mr. Dawkins has furnished me with the following list of Mammalia which have been obtained from the Brick-earth at Crayford:

Rhinoceros megarhinus.	*Elephas antiquus.*
——— *hæmitœchus.*	——— *primigenius.*
——— *tichorhinus.*	*Equus caballus.*
Ovibos moschatus.	*Felis leo* (var. *spelæa*).
Bos urus.	*Canis lupus.*
—— *bison.*	—— *vulpes.*
Cervus elaphus.	*Arvicola.*

IX.—Ice Scratches in Derbyshire.

By the Rev. T. G. Bonney, M.A., F.G.S.

At page 440, Vol. II., of the Geol. Mag., is a very careful and accurate description, by Mr. A. H. Green, of certain markings on an exposed rock near Matlock, locally named the Bloody Stone. These markings he refers, though not without some hesitation, to the action of ice. I have lately visited Matlock, and twice examined this spot. On the first occasion the surface was wet from recent rain, on the second it was dry.

It was at once obvious that, as Mr. Green has stated, "these markings must be one of two things, either ice scratches or slickensides." At the first glance the former seemed the most probable, but a closer examination caused me to incline ultimately very strongly to the latter, and for the following reasons:—

The chert appeared in several places to occur rather as a super-

[1] Dawkins, Geol. Journ., vol. xxiii., p. 101.

[2] See Mr. J. Brown's section in the writer's notes on Clacton.—Geol. Mag., Vol. V., p. 213.

ficial film, than as an intimate part of the rock, reminding one of the way in which slickenside galena is occasionally found. A close examination of the striæ showed—after discarding some which may safely be ascribed to the hobnails of 'historic' men—that they were rather flutings *in*, than scratches *on*, a polished surface; that is, that the small grooves themselves were polished: one of the best distinctions that I know between slickensides and ice-striæ in hand specimens. Again, it was very hard to understand how two such perfect surfaces could coexist if they had been produced by berg or glacier. Both occurred on exposed spots in juxtaposition, well developed, one might say brightly polished. They could not have been simultaneously produced. How then did the former set escape obliteration, or at least great injury, during the production of the latter? We cannot explain this by the well-known fact that stones in boulder deposits often have more than one set of markings; for these are mere scratches, unaccompanied by a corresponding polishing of such a hard surface as chert. But two or three different planes of slickensides do coexist in the same mass of rock. On closely examining the polished surfaces on the Bloody Stone, I observed that occasionally they appeared to dip into the rock, suggesting that if we broke it (which I did not think it right to do) we should find them pervading the mass. Again, I found in the middle of a surface, striated in one direction, an irregular pit or depression, produced apparently by a part of the rock having flaked off, in which the striæ ran in the other direction. (Mr. Green, by careful measurement, made out three directions of striation, two of them, however, are sufficiently near together to produce the general impression of two directions only, one roughly down, the other athwart the valley.) Now the polished surface could in these cases be sometimes traced quite close to the inclosing wall of the depression, which was occasionally nearly half an inch high. I also found the polishing more than once quite close to the foot of small, rough, projecting knobs of chert. Indeed I may venture to say that I found the polished striations in four or five places at least where a large mass of ice could not have produced them. In short, there was something in the general appearance and mode of occurrence of the markings which, though it can hardly be explained in words, was to my eye not consistent with their being ice-marks, and with these I happen to be very familiar.

About 30 feet lower down on the hill-side the adit of a mine has been begun. I examined this, and found within the entrance, and so, undoubtedly, in the mass of the rock, a set of slickensides on chert, running roughly north and south, and in a plane inclined at a small angle with the vertical, and so not far from at right angles with the surfaces in which the others occur.

I am, therefore, driven to the conclusion that these curious markings are not ice-striæ, but slickensides; though, so far as my experience goes, a very unusual instance of this structure, and suppose that it must have been exposed in making or enlarging the road, which runs exactly over the boss of rock.

X.—Supplementary Note on *Phaneropleuron* (Huxley), and *Uronemus* (Agass.).

By Prof. R. H. Traquair, M.D.

SINCE the publication of my paper, entitled "Notes on the Genus *Phaneropleuron*, with a Description of a New Species from the Carboniferous Formation," in the Geological Magazine for December, 1871, pp. 529–535, Sir Philip Egerton has kindly sent me for comparison a specimen in his collection of the Burdiehouse fish, named by Agassiz *Uronemus lobatus*, at the same time directing my attention to the resemblance which it bore to the fish which in the paper referred to I had described and figured as *Phaneropleuron elegans*. I am also indebted to the Earl of Enniskillen for an opportunity of examining another specimen of the same fish.

From these specimens it is evident that my *Phaneropleuron elegans* is identical with *Uronemus lobatus* of Agassiz. *Uronemus lobatus* was catalogued by Agassiz [1] as one of his family of Cœlacanths, but was not figured, and can hardly be said to have been described by him, as he gave no detail concerning it. I may therefore quote his entire description in full. "Le genre Uronemus se distingue par sa longue dorsale, qui commence presque à la nuque, et se continue sans interruption jusqu' à la caudale; l'anale n'est pas non plus séparée de la caudale. Ce genre ne renferme que de petits poissons de l'époque bouillère. J'en connais assez bien un espèce du calcaire de Burdiehouse à laquelle j'ai donné le nom de *Uronemus lobatus*." [2]

In his well-known Essay on the Classification of the Devonian fishes, Professor Huxley remarks that he had not seen *Uronemus*, and leaves it an open question whether or not it belongs to the family of *Cœlacanthini* as limited and defined by him, seeing that no details concerning it were given by Agassiz.[3] It is now, however, evident, from the specimens which I have described, that *Uronemus* is not a Cœlacanth, in the present acceptation of the term, but is a member of the family Phaneropleurini, closely allied to it, if not generically identical with the Phaneropleuron of Dura Den. Though, with the material at my disposal, I considered myself justified in describing the fish in question as a second species of *Phaneropleuron*, yet I must own that the Burdiehouse specimens are sufficiently imperfect as to detail of head, and as to evidence of a separate anal fin, as to render it very possible that better examples may subsequently demonstrate decided generic distinctions between them and the Dura Den fish. If, indeed, Agassiz be right in stating that the anal fin is continuous with the caudal, the distinction is sufficiently evident, but on this point I have never felt sufficiently satisfied.

In these circumstances I must consider it better that the Dura Den and Burdiehouse fishes should remain in the mean time under the names originally bestowed on them, and am therefore ready to withdraw the name of *Phaneropleuron elegans*, which I had given to the latter.

[1] Poissons Fossiles, vol. ii., pt. ii., p. 180.
[2] Op. cit., p. 178.
[3] Decades Geol. Survey X., p. 20.

Lord Enniskillen's specimen of *Uronemus lobatus* is four inches and a half long; the extremity of the tail is however deficient. At the very front of the snout, the impression of a small portion of bone is seen, whose edge must have been set with a row of small pointed teeth, these also being only seen in impression. About three-quarters of an inch back from the end of the snout, and in the middle of the confused and unreadable mass of bony matter representing the head, are distinctly seen several conical smooth tooth-like bodies one-fourteenth of an inch in length. They are apparently in an upper and lower opposing set; the upper are evidently palatal the lower may appertain to the lower jaw. Possibly they may be denticulations of Ctenodont plates, but from the state of preservation of the head, it is hardly possible to say so with certainty. The specimen is rather injured on the hæmal aspect of the caudal region, so that no additional information regarding the anal fin is gained from it, nor from the other specimen in the cabinet of Sir Philip Egerton. The latter measures three inches and a half in length. The head and the anterior part of the trunk are wanting, but the tail is shown to nearly its termination; the greater part of the dorso-caudal fin is present, but the lower lobe of the caudal is rather deficiently exhibited. This specimen shows, however, a well-marked, narrow, lanceolate, ventral fin one inch long, and three-sixteenths of an inch broad at its middle. Many of its fine rays are visible, but the state of preservation of the fin is unfortunately not sufficiently good to enable one to recognize its exact structure, though its general aspect is certainly that of an acutely lobate member.

NOTICES OF MEMOIRS.

I.—Discovery of a Human Skeleton in a Cavern in Italy.

THE announcement has been made, in "La Courrier de Menton," of the 7th of April, of the discovery of a human skeleton, in one of the caves of the frontiers of Italy, by Monsieur E. Rivière, who is entrusted by the French Government with a scientific mission —having for its object the study of the natural and prehistoric history and palæontology of Liguria.

Subsequently to the discovery, in the neighbouring quarries, of an immense quantity of bones, teeth, and fossil horns, of gigantic stags, rhinoceros, hyænas, bears, and other quadrupeds, sent by him to the national museum, M. Rivière has devoted himself, latterly, to the opening of caverns. The skeleton which he has just discovered was found in the large cavern of Baoussé-roussé, buried beneath a layer of earth several yards thick. This cavern is called, in the dialect spoken at Grimaldi, the "Barma du Cavillon"; that is to say, the cavern of the little cheville (*barma* signifying cavern, and *cavillon*, the diminutive of *cavilla*, bolt), a name given to it from time immemorial, because there has always been a piece of wood placed transversely over the front. This was destroyed when the

Fossil Human Skeleton found in the Cavern of Baoussé-roussé, near the Railway from Mentone to Vintimille.

railway was made from Mentone to Vintimille. In front of the cavern, and at a distance of five or six yards from the place where the recently-discovered skeleton was met with, there was, sixty years ago, an immense carob-tree, which almost entirely blocked up the mouth of the cavern, and gave it a sombre and dismal appearance.

The state of preservation of the skeleton is very remarkable and astonishing, seeing that its age, which it is impossible to estimate with exactitude, must extend backwards into pre-historic times. This extraordinary state of preservation may possibly be explained by an analysis of the earth in which it was found, and the uninterrupted dryness of the sheltered spot in which it was placed.

The careful way in which the surrounding ground has been cleared away, has had the effect of preserving the position which the skeleton has retained ever since it has occupied the spot where it was found. With the exception of the fragile ribs, which have been broken by the pressure of the overlying soil, the subject is entire. The legs crossed in a natural position, and the two arms folded near the head, seem to lead to the conclusion that the man to whom they belonged died in his sleep, and that he had been carefully covered with earth, without disturbing the ground beneath. The thigh-bones measure 16 inches in length from one extremity to the other, and the rest is in proportion—or in other words, the skeleton is that of a man of ordinary stature. The teeth and the lower jaw are in a very good state of preservation. The cranium, of average size, is of a dark brick-red colour, and the part resting on the ground is broken by pressure. Its colour, different from that of the other bones, does not seem capable of positive explanation. There is an immense number of small shells adhering to the cranium, leading one to suppose that these shells, all drilled with a hole, have been used for ornament, either twined in the hair or as part of a head-dress.

Round the skeleton were found several flint implements, such as scrapers, chisels, and axes, together with bone needles, the curious fashioning of which seems to have been effected by rubbing or grinding down on some hard substance. There were also found the bones of animals, and, amongst others, the lower jaws of herbivora. Behind the head a stone was met with, another behind the loins, and between the former and the head two stone implements of the largest size found in these caverns.

All the curious objects which have been discovered by Dr. Rivière, have been photographed by an able operator, M. Anfossi.

H. W. Bristow.

II.—Paléontologie Française, ou description des Fossiles de la France, continuée par une réunion de Paléontologistes, sous la direction d'un Comité Spécial. 2me érie—Végétaux. Plantes Jurassiques. Par M. le Comte de Saporta.

THIS work of mine, of which I would give a sketch to the readers of the Geological Magazine, treats of the group of fossil plants of the French Jurassic period. I should not have undertaken it had I not received the friendly co-operation of a large number of geologists, who have liberally given me access to their collections, as well as the patronage and advice of M. Ad. Brongniart.

By a coincidence which it is natural to mention here, the *Histoire des Végétaux Fossiles*—the eminent but incomplete work of the illustrious French savant—stops just towards the end of the Cryptogams, and thus excludes the greater number of the Jurassic species, some because they belong to the class of Gymnosperms, others because they were not known at the time when M. Brongniart published his *Histoire.* This work is thus taken up almost at the point where M. Brongniart's has left off. The need of the publication is obvious from this statement; the subject is in itself interesting. The Jurassic period, from a biological point of view, constitutes a kind of middle age, equally distant from the Palæozoic and Neozoic periods. It serves, so to speak, as a hyphen between epochs which, without it, would present a complete contrast; but this hyphen itself corresponds to a very long period.

The configuration of the European land modified several times, the deposits varying in their nature and aspect, new series of marine animals substituting themselves for former ones, and eliminated in their turn by others,—all these phenomena, by their intensity and repetition, bear witness to the immensity of the period. Nevertheless, it is to be observed, that the vegetation appears to have changed less than anything else. Not only has it preserved longer than the population of the sea the species it contained at a given time in the period, but its general characters and the relative disposition of its elements have suffered far less alteration from the lapse of time; in a word, it has remained almost stationary from one end of the period to the other, instead of visibly progressing, as is proved, respecting the Cretaceous plants, by comparing those which existed in the Wealden with the Flora of the white Chalk or Santonien. That is, in my opinion, the principal feature of the Jurassic vegetation. Consult from this point of view the Keuper, the Rhætic, the Oolite, or the Wealden; that is to say, place yourself in the age which immediately precedes the period, at its beginning, middle, or even at the end, there is almost always the same general physiognomy to be observed; and the Ferns, the *Equisetaceæ*, the *Cycadaceæ*, and the *Coniferæ*, that one meets, are combined in relative proportions which vary very little. A second phenomenon, which is not without connexion with the last, consists in the recurrence of similar, but not absolutely identical forms, although it is difficult at times to distinguish them, which have just shown themselves in successive stages separated by intervals more or less long, as if the same forms re-appeared still recognizable, although slightly modified.

It is thus that several Rhætic species seem to re-appear in the Oolite, and some of these, like the *Baiera digitata*, Schimp., to return in the Wealden under the name of *Baiera pluripartita*, Schimp. One cannot reasonably assign to these singular parallelisms, which I have attempted to sum up, any other cause than the persistence or the reproduction of the same physical conditions, bringing with it the preservation or the return of the same organic combinations.

Considered as a whole, the Jurassic vegetation seems to have been poor, monotonous, and almost entirely composed of tough plants with hard and meagre foliage, little capable of furnishing nourishment to animals. Thus the contemporary terrestrial animals were generally carnivorous, and the mammifers particularly nearly all insectivorous. The small dimensions of most of the plants of this epoch result from the comparison of their different organs with those of species which correspond to them in the same natural Order. The largest Jurassic *Cycadaceæ* are not equal to those of our time; several were far smaller, or even were only a few inches high. So also with a great number of Ferns. We do not find in the plants the gigantic proportions assumed by the greater number of the contemporary reptiles. However, to avoid exaggeration, we must state that the fronds of some ferns must have measured a considerable size in their integrity, and that the *Coniferæ*, especially the *Cupressinites*, present arborescent types of the first magnitude. Nevertheless, when one studies the Jurassic plants closely, nothing rich or luxuriant discloses itself, and one is struck by the extreme simplicity of the group. *Equisetaceæ*, Ferns, *Cycadaceæ*, *Coniferæ*, some rare Monocotyledons, are the sole constituent elements of the terrestrial vegetation. Add some rather rare *Characeæ* and *Algæ*, and we shall have enumerated all the Orders of plants which peopled the land and waters of our country at that period. These are some of the most startling peculiarities that the study of these diverse groups brings to light.

The list of *Algæ* is in accordance with the importance of the marine deposits and the predominance of the seas, at an epoch when central Europe still formed an archipelago, whose islands tended to unite themselves without being definitely welded into a single continent. To explain the method of determination which I have applied to the Jurassic *Algæ* would carry this beyond the bounds of a simple notice. It is very evident that the greater number of these plants *must* have perished without leaving any trace. The impressions which have come down to us are all the more interesting, and—irrespective of doubtful forms which the desire of being complete urges an author to describe, without having a very lively faith in the objects which he desires conscientiously to make known—there exist others that are trustworthy; an examination of these suggests many curious remarks. Thus the class of *Algæ*, conformably with what has taken place in the greater number of marine organisms, has altered very gradually, and the obstinate persistence, so to speak, of certain types of Jurassic *Algæ*, establishes this in a surprising manner. In support of this I will adduce three kinds of *Algæ* chosen from those best characterized: to two of them I have given the names *Siphonites* and *Cancellophycus*; the third is the large genus *Chondrites*, Sternb., several times altered, but very natural when we only include species with the same facies. The connexion between *Chondrites* and the existing *Gigartinæ* is the more probable, as several of the Jurassic species exhibit globular swellings, very analogous to the *Sporangia* of the living members of this family. The *Chondrites* were without doubt true *Florideæ*, with stiff cartilaginous fronds like those of *Chondrus*, *Gelidium*, *Gigartina*, etc. Their development reaches its height in the Jurassic period; but, far from being limited to that period, they extend into the Chalk, and appear anew in the Flysch, towards the middle of the Tertiary epoch. The forms under which they then show themselves are so similar to those which they had in the Jura, that there necessarily exists much confusion between the species of the two ages, which is difficult to unravel, but which witnesses at least to the persistence of the genus during a prodigious space of time. The origin of the *Chondrites*, certainly previous to the Jurassic period, is connected with the very origin of organic life, since it seems more than probable that one part at least of the Silurian *Bythotrephis* of J. Hall, and especially *B. gracilis*, with its varieties, differ in no respect from true *Chondrites*.

Siphonites Herberti, nov. sp., an Alga, with a simple cylindrical and fistulous frond, closed at the top like the finger of a glove, more or less allied to *Codium*, and therefore to *Caulerpites*, has been found by M. Hérbert at the very base of the Lower Lias; it has an incontestable affinity, approaching to identity, with the *Palæophycus virgatus*, J. Hall, a Silurian species which comes from the same American beds as the *Bythotrephis*.

Cancellophycus, so widely spread over the bosom of the Jurassic seas, and of which *Chondrites scoparius*, Thioll., is the type, is allied, like *Chondrites* and *Siphonites*, though in a less direct manner, to Palæozoic genera, particularly to *Spirophyton*, Hall, of the American Devonian, to the *Alectorurus*, Schimp., of the Swedish Silurian, and above all to the *Caulerpites marginatus*, Lesq. (*Physophycus*, Schimp.), of the Carboniferous of Pennsylvania. The fronds of *Cancellophycus* were fixed by the centre or the base, and formed a foliaceous expansion, more or less scalloped or lobed at the margin, with rows of perforations disposed in ramified lines radiating from the point of attachment, spirally twisted, or rather folded back on themselves from the periphery. The substance of these fronds, probably of a cartilaginous nature, was thus perforated with a multitude of narrow and regular openings, as if made by a punch. This type, which in one direction mounts to the Silurian, shows itself in an opposite direction in the midst of the Flyschian sea. Amongst the existing Algæ, the most analagous is *Thalassophyllum clathrus*, Post. and Rupr., a species of the family of *Agari*, and of the order of *Laminariæ*, which inhabits the coast of Kamtchatka, and the fronds of which, pierced with regular perforations larger than those of the fossil fronds, attain a diameter of six feet. It is probable from this resemblance that the *Cancellophycus*, like the *Agari*, have formed part of the group of *Laminariæ*, or at least of a group allied to it.

The *Algæ* of the Secondary seas comprised then, according to all appearance, Zoospores and Florides. The presence of *Dictyotaceæ* at the same epoch is proved by the *Fucoides erectus*, Bean (T. Leckenby. Oolitic Plants, Quart. Journ. Geol. Soc., vol. xx., p. 81, tab. xi., figs. 3*a* and 3*b*), a species from the Great Oolite of Scarborough, in which M. Schimper has recently recognized a veritable *Haliseris.* The Fucaceæ, properly so called, on the contrary, would apparently have still been absent, and this absence would support the opinion of those who recognize in them the most highly organized of all the *Algæ.* The same appearance is not presented on the land; we may say that it varies according to the groups we examine. The persistency of the structure of *Equisetum* is well known; those of the Jurassic epoch are distinguished by their great height, sometimes relatively gigantic, a characteristic nevertheless that would not apply to all the species. The Ferns present a singular combination of extinct types, and types whose affinity to those of the present day cannot be mistaken. *Clathropteris, Thaumatopteris,* and several other genera with reticulated nerves, whose fructification have recently been observed, are scarcely distinguishable from the living *Drynariæ,* with which we should perhaps have classed them if there had been fossil species. We might state also that several *Tæniopteridæ* range themselves without much effort by the side of *Marattia Danæa* and *Angiopteris,* and consequently amongst the *Marattiaceæ;* but besides these partial assimilations, which the discovery of organs of reproduction has legitimized, there exist a number of types that we are compelled to group artificially, so uncertain are we still on the subject of their true affinities. Respecting many of them, one would be even compelled to believe that they are really without any actual affinity to any of the living genera capable of being compared to them. Hence the method of classification, founded by M. Ad. Brongniart, and based solely on the characteristics of the nervation, takes the precedence, and ought to be exclusively employed as the only one which does not lead to erroneous results.

The Jurassic Ferns of France comprise a moderately large number of species, and even of entirely new genera. I would here offer an explanation of those differences which are calulated to strike the mind when one proceeds to enumerate the different local vegetations.

Several of the localities whence the French fossils come, amongst others that of Hettange (Moselle), of Chatillon-sur-Seine, of Lourdines (Vienna), of Saint-Mihiel (Meuse), etc., represent ancient sea-shores where the mere action of the water washing away the earth and of the wind have contributed to carry the plant to the bottom of deep creeks and bays filled perhaps with a pure chalky slime or fine mud hereafter converted into sandstone. The plants collected under these conditions differ more or less from those which we meet with in the marly and bituminous schists which must have been deposited at the bottom of the peaty lagoons or estuaries of that epoch. It is to the formation of this last kind that it is expedient to ascribe the Rhætic Flora of Franconia, and that of the Oolite of Scarborough. These floras have transmitted to us the vestiges of a fresh and luxuriant vegetation, whose growth was favoured by the influence of the waters, and which was without doubt quite distinct from that which covered the interior of the lands. It is, on the contrary, that second vegetation to which I may naturally apply the name of *sylvan,* because it extended uniformly over the surface of the Jurassic regions, of which the fossils collected in France most often convey the appearance. The first restricted to the watered places occupied only the bottoms of valleys, the neighbourhood of waters, and the edges of the mouths of rivers. Tough Ferns, of small and ordinary growth, monotonous in aspect, often however generically distinct despite this monotony, together with Cycads scarcely varying, and Conifers of full stature, compose the group of *sylvan* flora, the details of which change more than their fundamental structure as one passes from one stage to another.

I will say little on the subject of Cycads, to which I purpose returning later. The discovery of some of their organs of fructification, the minute observation of their trunks, of their mode of growth, and of the relative peculiarities of the development of their leaves, will lead without doubt to a satisfactory solution of questions quite as obscure as those which their determination raises.

For the present we must believe that the Cycads of Jurassic Europe are not directly allied to any of those now existing. The living Cycads occupy, in small scattered groups, some Central America and the dependent islands, others Southern Africa, others again the islands of India and Japan, or finally New Holland. Each one of these regions, it must be remarked, possesses special genera of Cycads. There is then nothing surprising in the fact that our continent has in times past possessed its own Cycads, represented by genera peculiar to itself.

The examination of the Conifers would carry us further still; besides, their study is far from complete; and it will be time, when this has been done, to state the definite results. One must admit as probable that in the Lias ambiguous types have entirely disappeared, the last continuations of the *Walchia* of Permian strata, of *Voltzia* and *Albertia* of Keuper, and the first outlines of groups which perfected themselves afterwards, and still occupy the earth; whilst in the Oolite the oldest *Araucaria* and *Sequoia* show themselves related to the true *Cupressinites*, more or less allied to the existing *Thuyiopsis*, *Retinospora*, and *Widdringtonia*. They were without doubt the only large trees of those past times, under whose shade the other plants took shelter. The climatic conditions were still far from what they have since become; nothing resembling the Zones disposed after the manner of latitudes then existed; and a sensibly equal heat stretched over every part of the globe. Nevertheless, it does not seem to follow from the examination of the indices furnished by the plants, that the temperature of Europe would at that time have been higher than that which countries situated near the tropics now enjoy. An annual mean of 77° Fahr. suffices to explain all the phenomena which the Jurassic vegetation displays.

SAPORTA.

III.—A Sketch of the Geology of the Neighbourhood of Banbury. By Thomas Beesley, F.C.S.

Read at the Annual Meeting of the Warwickshire Naturalists' and Archæologists' Field Club, at Warwick, 5th March, 1872.

THE district described by the author is that on either side of the River Cherwell, which rises twelve miles E.N.E. of Banbury, and joins the Thames near Oxford to the south; the valley in which it flows gradually narrowing in that direction, while to the north it is spread out, and almost divided into two portions by a ridge of Lias Marlstone; extending from Hardwick to Fenny Compton, this formation also forms the table-land on either side of the valley.

The lowest zone of the Lias visible at Banbury is that of *Ammonites Henleyi*, from which beds the author obtained 103 species of fossils and a large number of Foraminifera; he describes the beds as consisting of dark-blue shaly marls, with occasional septaria and nodular phosphatic concretions, with a thin bed of hard grey shelly Limestone near the top, known as "Banbury Marble."

From the *Capricornis* zone, visible in the brick-yard, by the west side of the canal, south of the town, he obtained 25 species, amongst them *Cardium truncatum*, *Modiola cuneata*. The *Am. Jamesoni*, *Henleyi*, and *Capricornis* zones the author calls the Lower Middle Lias, to distinguish them from the Marlstone rock-bed and its underlying marls; the last two zones he considers to be forty feet in thickness.

His *Upper Middle Lias* is made up of the *Am. margaritatus* beds of Twyford Wharf, south of Banbury, with 40 species of fossils, and the Marlstone rock-bed or zone of *Am. spinatus*, which is about twelve feet in thickness, and forms a broad table-land on the south and west, and a terrace on the east side, the disintegration of which has formed the rich red wheat-growing land, described by Arthur Young "as the glory of Oxfordshire." On Edgehill escarpment it rises to an elevation of 720 feet above the sea-level, dipping down to 500 feet at Banbury.

The following section is given of the Marlstone at the King's Sutton ironstone-works:—

	Ft.	In.
Soil, sandy and ferruginous	2	6
Upper *Rhynchonella tetrahedra* bed (Marlstone)	0	8
Marlstone	2	6
Lower *Rhynchonella* and *Terebratula* bed (Marlstone)	1	0
Marlstone with concretions...	1	0
Rusty ferruginous concretions	1	8
Sandy blue marl and grey shale		

The concretionary nodules are rich in phosphates, and are, no doubt, partly the cause of the fertility of the marlstone soil. Silicate of iron grains often occur, so as to give almost an Oolitic structure to the Marlstone; these grains are sometimes hollow, and appear to have been moulded upon the shells of Foraminifera and Entomostraca. The rock-bed is a sandy ferruginous limestone, brown outside, and greenish blue in, separated by thin partings of sandy loam and clay. North and west of Banbury the rock becomes thicker, and is largely quarried for paving, troughs, and gravestones. The Hornton stone has been much used in the old churches, and wears well.

Large excavations have been made in the marlstone on both sides of the valley at Adderbury and King's Sutton, four miles south of Banbury, near the Great Western Railway and Canal, for the purpose of smelting to obtain the iron which is found in the Marlstone, in variable proportions, that of King's Sutton ranging from 18·7 to 25·5, and even to 34 per cent. of iron, but the richer samples are very sandy.

When richest it will yield as much, according to Prof. Phillips (Geol. of Oxford, etc.), as "30,000 tons to the acre, every three tons of the best samples producing one ton of iron."

From the Marlstone beds Mr. Beesley obtained 69 species of fossils, and from the whole Middle Lias 190; from the Adderbury quarry he mentions a large trunk of Coniferous wood, and describes drift-wood as common in the Marlstone.

Detached outliers of Upper Lias occur on Crouch and Constitution Hills, on the Marlstone plateau, and fringes along the slope of the valleys to the west, reaching a thickness of 100 feet of blue whitish clay, with earthy limestone separated by thin shales.

The *Saurian and Fish zone* of Somersetshire was discovered by Mr. Beesley, at Middleton Cheney and Thenford to the east, and by Mr. Judd, F.G.S., at Sibford, seven miles west of Banbury. The "Upper Cephalopoda beds" of Somersetshire, described by Mr. Moore, F.G.S., are constant in the former district; from these Upper Lias beds were obtained 124 species, including 2 vertebrata and 2 corals. Two years ago it was shown by Mr. Judd, late of the Geological Survey, and by Mr. Sharp, F.G.S., of Dallington, that the Northampton sands (which, in opposition to the views of Dr. Lycett, Prof. Morris, and the Rev. P. B. Brodie, have been held by many eminent geologists to be the base of the "Great Oolite"), were really the *Inferior Oolite.* Mr. Beesley has not only been able to confirm this, but has discovered the Inferior Oolite rock-bed, probably a part of the Freestone division.

The marlstone plateau to the south is bounded by the Northampton Sands "from Swerford on the west, by Great Tew and Dun's Tew to near Deddington." It also forms the east and west slopes of Constitution Hill, where loose sandy beds occur; at Milcomb Hill are sandy limestones, and at Sibthorp a light brown thick-bedded limestone is quarried for building. The sandy beds sometimes reach a thickness of 30 feet, and are of a red, orange, grey, or white colour.

In the limestones occur, *Am. Murchisonæ, Hinnites abjectus, Ostrea costata, Terebratula perovalis, Rhynchonella sub-decorata, Montlivaltia De-la-Bechei,* &c.

At Combe Hill and Blackingrove limestone beds let in by faults (originally mapped however by the Geological Survey as "Northampton Sands") have been proved by Mr. Beesley to be undoubtedly Inferior Oolite. From the Combe Hill beds he has collected 65 species of fossils, most of which were determined by Mr. Etheridge, F.R.S. The collection includes a new *Trigonia,* which will be described by Dr. Lycett in his monograph on the *Trigoniadæ.*

The thickness of the Great Oolite cannot be measured, owing to faults. It is probably about 50 feet. The limestone is earthy, compact, white outside, and blue within. It is never a freestone, but occasionally contains hard shelly bands like Forest Marble, used for road-metal. The limestone at Tadmarton contains *Teleosaurus* *brevidens* and *subulidens*, and the whole section (but chiefly the above and Constitution Hill) has yielded 129 species. The base when seen invariably rests on a grey laminated sandy marl, resting on the Northamptonshire Sands.

In making a new branch railway recently at Greatworth, the Great Oolite was found to be eroded and smoothed by glacial action, and filled with drift. The base is a blackish clay, with abundant decayed glacial shells, above is a grey sand with a few shells, overlaid by gravels, clays, and sands, with pebbles and lumps of hard chalk, Permian sandstone, *Ostrea dilatata*, and Marlstone, mostly scratched.

Mr. Beesley describes the faults traced in the Geol. Survey Map, and also a small one, parallel with Broughton fault, from Broughton road across the low ground between Constitution and Crouch Hills, with a downthrow north of 30 feet. C. E. De R.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—March 20, 1872.—Prof. John Morris, Vice-President, in the Chair.—The following communication was read:—"On the Wealden as a Fluvio-lacustrine Formation, and on the relation of the so-called 'Punfield Formation' to the Wealden and Neocomian." By C. J. A. Meyer, Esq., F.G.S.

In this paper the author questioned the correctness of assigning the Wealden beds of the south-east of England to the delta of a single river; he considered it more probable that they are a fluvio-lacustrine rather than a fluvio-marine deposit, and attributed their accumulation to the combined action of several rivers flowing into a wide but shallow lake or inland sea. The evidence adduced in favour of these views was mainly as follows:—The quiet deposition of most of the sedimentary strata, the almost total absence of shingle, the prevalence of such species of Mollusca as delight in nearly quiet waters, the comparative absence of broken shells such as usually abound in tidal rivers, and the total absence of drift-wood perforated by Mollusca in either the Purbeck or Wealden strata.

This Wealden lacustrine area the author supposed to have originated in the slow and comparatively local subsidence of a portion of a land-surface just previously elevated. He considered that during the Purbeck and later portion of the Wealden era the waters of such lacustrine area had no direct communication with the ocean. The changes from freshwater to purely marine conditions, which are twice apparent in the Purbeck beds, and the final change from Wealden to Neocomian conditions at the close of the Wealden, were attributed to the sudden intrusion of oceanic waters into an area below sea-level.

The author then pointed to the traces of terrestrial vegetation in the Lower Greensand as evidence of the continuance of river-action after the close of the Wealden period.

In the concluding portion of his paper the author referred to the relation of the Punfield beds of Mr. Judd to the Neocomian and

Wealden strata of the south-east of England. From the sequence of the strata, no less than on palæontological evidence, he considered the whole of the so-called "Punfield formation" of the Isle of Purbeck to be referable to the Lower Greensand of the Atherfield section.

Discussion.—Mr. Godwin-Austen did not agree with Mr. Judd in calling the bed at Punfield the Punfield "formation;" it was merely a bed intercalated between beds of a different character below and above. There could be no doubt of the Wealden deposits extending over an area at least equal in extent to many of the freshwater lakes at present in existence; and the freshwater conditions exhibited by the Wealden must have been in existence during an immense length of time. At Punfield alone, however, was there evidence of the transition from freshwater to marine conditions, as the other reputed cases seem to be merely instances of landslips. The change from one condition to the other might, he thought, be due to a very slight depression. The Neocomian series, such as was known to continental geologists, could hardly be recognized in Britain; and it was only during the last portion of that period that any deposits took place in this country. The phenomena of the Wealden deposits might, he believed, be traced over a much larger area than was commonly supposed, and certainly as far as Saxony. He considered that the same area of land continued through both the Jurassic and the Cretaceous times.

Prof. Ramsay thought that the Purbeck strata were connected with lagoons in contiguity with a large river rather than with inland lakes. These, from time to time, owing to oscillations of level, were covered with marine deposits. He did not think that the absence of gravelly deposits offered any serious difficulty in regarding the Wealden strata as marine. It seemed to him more probable, however, that the sands and clays of the Wealden were due to some ancient rivers on a large scale, and deposited at their mouths, though in some spots the beds were subject to the action of fresh and salt water alternately. To the east of Oxford the Lower Greensand beds were found at first to contain marine shells; but as they proceeded eastward freshwater forms made their appearance, and in places at last predominated in beds of the same lithological character. He regarded the Neocomian as, to some extent, a marine representative of the Wealden, though of later date.

Mr. Etheridge recalled the fact that Mr. Judd had correlated the Punfield fossils with those of the north of Spain, twenty-two species found in each being absolutely identical. He argued from this that the extent of the beds may have been far larger than might be supposed. In Hanover the beds, characterized by different Ammonites, occurred in precisely the same order as in England at Speeton and elsewhere. He regarded the question between Mr. Judd and the author of the paper as not yet absolutely settled, though both had done so much for its elucidation.

Prof. T. Rupert Jones remarked that the Purbeck-Wealden lake theory had not only been intimated by several previous writers, but had been illustrated by maps by Messrs. Godwin-Austen and Searles Wood, Jun. Whatever the direction of the main rivers, and whatever the extent of the lakes, the Rev. Osmond Fisher had shown that one river came in from the west. Mr. Jones instanced, in support of the lake-theory, the occurrence of oysters, *Potamides*, and *Corbulæ* in the base of the Wealden at Pounceford; also the dwarf *Tornatella Popei* at Tunbridge Wells and Balcombe. He alluded also to the brecciated condition of some and the upturned position of other Wealden beds. In allusion to the small bivalve Entomostraca so often referred to, he regretted that they had not yet been fully described; a bed of them occurred in the Upper Portland at Hartwell before the Purbeck set in. He concluded by saying that such general papers as the one under discussion ought to have detailed references to the writings and opinions of previous observers.

Mr. Hulke referred to the question of gravels being present in the Wealden, which he stated were in some localities abundant, getting coarser in the beds furthest to the west. This increase in the coarseness of the gravel was suggestive of a river running from west to east. In the east of the Isle of Wight he had found remains of *Plesiosaurus*, a marine form, much more commonly than further west, which supported the same view. He mentioned beds between Brixton and Calbourne, in the Isle of Wight, which appeared to him strictly analogous to those in Worborrow Bay.

Mr. Jenkins disputed the identity of origin of the Purbeck and Wealden beds, lime being abundant in the former and comparatively absent in the other, and there being an equally marked difference in the organic contents of the two formations. He considered the Purbeck formation to have been deposited in a lagoon subject to occasional invasions of the sea, while the Wealden was in fact a large delta. Though both were of freshwater origin, they were deposited under totally different conditions.

The Chairman, alluding to the pseudomorphs of salt mentioned by the author, stated that they had been somewhat compressed, and thus modified in form. They had also been found in other beds in the Wealden. He commented on the extension of the Wealden strata even to the south of Moscow. In the Oxford and Buckinghamshire area there was evidence of great denudation of the Purbeck and Wealden beds prior to the deposit of the Neocomian, so that great changes would seem to have taken place, giving rise to a great amount of denudation towards the close of the Wealden period.

Mr. Meyer agreed with Mr. Godwin-Austen and other speakers as to there having been a certain amount of denudation of the Upper Wealden beds prior to the deposit of others upon them, but this he regarded as merely local. It was the absence of shingle rather than of gravel to which he had alluded in his paper. He thought that there was a distinction to be traced between the Neocomian of the north of England and that of the south, and that the middle beds of one were equivalent to the lower beds of the other.

II.—April 10, 1872.—His Grace the Duke of Argyll, K.T., F.R.S., President, in the Chair.—The following communication was read:—"Notice of some of the Secondary Effects of the Earthquake of the 10th January, 1869, in Cachar." Communicated by Dr. Oldham, of Calcutta, with remarks by Robert Mallet, Esq., C.E., F.R.S.

This earthquake was a severe one, being strongly felt in Calcutta, distant from the meizoseismic area about 200 miles, and far into the plain of Bengal.

The effects were examined on the spot a few weeks after the shock by Dr. Oldham, who anticipates being able to fix the position and depth of the centre of impulse by following the same methods as those first employed by Mr. Mallet with respect to the great Neapolitan earthquake of 1857.

These results have not yet been received; but Dr. Oldham has forwarded an extremely interesting letter on the circumstances of production of very large earth-fissures, and of the welling up of water from these, derived from the water-bearing ooze-bed, upon which reposed the deep-clay beds in which the fissures were formed.

Dr. Oldham rightly views all these fissures, which were all nearly parallel to and not far distant from the steep river banks, as "secondary effects," and not due to fractures produced by the direct passage of the wave of shock. He also shows that the welling up or overflowing of the water in the fissures was a secondary effect also, and negatives the notion entertained on the spot of mud-volcanos, etc., having originated at those fissures.

The chief aim of Mr. Mallet's remarks was to point out the importance to geologists of rightly comprehending the dynamics of production of these phenomena, and to show that the older notions of geologists as to earthquake-fissures are untenable. He explained clearly, aided by diagrams, the train of forces by which the elastic wave of shock, on passing out of the deep-clay beds where these have a *free side* forming the steep river banks, dislodges certain portions and throws them off towards that free side—and that this is but a case of the general law in accordance with which such elastic waves behave towards more or less incoherent deposits reposing on inclined or on level beds, under various conditions.

Mr. Mallet also explained the dynamic conditions under which the water from water-bearing beds, such as that of ooze beneath the Cachar clay-beds, becomes elevated in the fissures formed, and gave approximate expressions for the minimum height to which the water can rise in relation to the velocity of the elastic wave particle. The paper concluded with remarks upon the continual noises, like the irregular fire of distant artillery, heard long after the shock had passed, and when the country had become perfectly quiescent.

Discussion.—Mr. Scott wished to ascertain the author's opinion as to the possibility of predicting earthquakes on meteorological grounds, as had been done by M. Boulard, several of whose prophecies were said to have been fulfilled.

Mr. D. Forbes gave some details of the earthquake of Mendoza, a town situated on a vast alluvial plain at the foot of the Andes, in which the phenomena remarkably coincided with those detailed by Dr. Oldham. In that case he found that the rumours as to fire and smoke having been emitted from fissures were entirely without foundation, the presumed smoke having been nothing but dust. The earthquake was felt over a distance of 1200 miles; and wherever the firm rock came to the surface there was no trace of fissure, though portions of the rock were overthrown. But in the plain, consisting of 30 or 40 feet of alluvial soil, the whole ground was in places fissured, and in some districts the surface completely furrowed, and even the turf turned over. He had witnessed numerous earthquakes, and in some cases had been in deep mines during their occurrence, when the sound only could be heard, and he could testify to their effects being confined to the surface. The direction of the fissures was invariably at right angles to the line of shock. In South America all the earthquakes could be traced to volcanic centres.

The President inquired as to the distinction to be drawn between the primary and secondary effects of earthquakes, and whether the author thought that no fissures were attributable to the direct action of earthquakes; also as to the cause of the sounds.

Mr. Mallet, in reply, explained that fissures only take place where masses were comparatively free in one direction. They might extend to enormous depths, though they often closed in rapidly. With regard to the power of predicting earthquakes, he disbelieved in it wholly, and considered that any fulfilment of such prophecies must be due to accident; earthquakes are so numerous, that the chances of such fulfilments are great. The blow or impulse originating earthquakes could not be attributed solely to one cause. It arose often from deep subterranean volcanic action, but it also—especially in the case of long-continued tremors, like those of Comrie or Pignerol—arose from the breaking up or the grinding over each other of rocky beds at a great depth, through the tangential pressures produced in the earth's crust by secular cooling. The arrested impulse of the fall of the Rosberg in Switzerland produced a sensible earthquake. Fissures in hard rock could not be produced *directly* by the shock, because the velocity of impulse in such rock greatly exceeded that of the elastic wave particle. The earth's crust was at present not in a state of tension, but of compression, through secular cooling.

III.—April 24, 1872.—Prof. Ramsay, F.R.S., V.P., in the Chair.—1. "An extract from a despatch from H.M. Minister in Teheran." From the Right Hon. the Earl Granville, Secretary of State for Foreign Affairs. It described the effects of some severe earthquake shocks experienced at Khabooshan, in North-Western Khorassan. On the 23rd December, 1871, an earthquake occurred, which destroyed half the town of Khabooshan, and buried about 2000 of its inhabitants in the ruins. On the 6th January, 1872, another severe shock destroyed the remainder of the town, and killed about 4000 people. Four forts near the town were so completely buried that not a trace of them can be seen. It was estimated that 30,000 lives were lost in Khabooshan, Bojnoord, and the surrounding villages, by the effects of these earthquakes.

2. "On the Geology of Queensland." By R. Daintree, Esq., F.G.S. The author stated that alluvial deposits are very scanty in Queensland, except on the northern shores of Carpentaria and near the mouths of the larger rivers. The fossil remains of extinct Mammalia (*Diprotodon, Macropus, Thylacoleo, Nototherium,* etc.) are found with shells of existing species in brecciated alluvia, representing beds of old water-courses, through which modern creeks have cut their channels.

Of Cainozoic deposits the most important is called the "Desert Sandstone" by the author; it consists of horizontal beds of coarse grit and conglomerate, nowhere exceeding 400 feet in thickness, forming a sandy barren soil by their disintegration. The only fossils found in it are rolled fragments of Coniferous wood; and its stratigraphical position is determined solely by its resting unconformably upon beds containing Cretaceous fossils. The author considered that this deposit formerly covered nearly the whole of Australia.

Beds containing Mesozoic forms of fossils, and referred by the author to the Cretaceous series, occur upon the Upper Flinders. At Marathon these deposits consist of a fine-grained yellow sandstone, and below this a series of sandstones and argillaceous limestones, containing four species of *Inoceramus,* with a species of *Ichthyosaurus* and two of *Plesiosaurus.* At Hughenden station, near Mount Walker, there is a series of calcareo-argillaceous beds, probably inferior to those of Marathon, and containing two species of Ammonites, with *Avicula gryphæoides,* a *Pecten,* etc. At Hughenden cattle station, twenty miles further up the river, numerous Belemnites are found loose upon the surface. These Mesozoic rocks also extend down the Thompson River and its tributaries. The author referred to the fossils described by Mr. Charles Moore as probably Oolitic, and stated that it is more than probable that Oolitic and Cretaceous rocks extend throughout the whole of Central Queensland, and thence to Western Australia. On the eastern side of the dividing range a small patch of ferruginous grit containing *Panopæa plicata,* occurs near Pelican Creek; and from Gordon Downs species of *Panopæa, Pholadomya,* and *Cucullæa* have been obtained. These beds probably represent a lower horizon than those on the Flinders River; and a large portion of the colony east of the dividing range is covered by freshwater deposits, containing plant-remains (including *Tæniopteris*), and in their upper part a fauna apparently intermediate between the Gordon Downs and Flinders River series. In these deposits, on the Condamine, Brisbane, and Mary rivers, numerous coal-seams exist. The author supposes that, contemporaneously with the deposition of a series of marine beds to the west of the dividing range, during the Oolitic and part of the Cretaceous period, a vast lacustrine deposit was to the eastward of the range, to which the sea subsequently obtained access.

Among the Palæozoic deposits, the author distinguished Carboniferous and Devonian rocks. The Carboniferous series was said to be represented in northern Queensland by an extensive coal-field. The upper portion of the series (grits, sandstones, and shales) contains chiefly fossil plants, the most abundant being a *Glossopteris*. The lower strata (generally argillaceous limestone) contain *Producti*, *Spiriferœ*, etc., of true Carboniferous type, intermixed with scanty and imperfect remains of the above-mentioned plants. A set of fossils from the head of the Don River were said to agree with those found in the Hunter River series of New South Wales.

Devonian rocks extend from 18° S. lat. to the southern boundary of Queensland and for 200 miles inland. They consist of slates, sandstones, and Coral-limestones. The upper portion of this series contains an abundance of fossil plants, the deposits containing which, at Mount Wyatt, are interstratified with beds containing *Spiriferœ*, and other fossils of Devonian type occur in beds reached by shafts sunk through these strata. In the limestone of the lower portion of the series seen on the Broken River corals are very numerous. Gold is found in many parts of the Devonian district, and the author entered in considerable detail into its mode of occurrence there.

Metamorphic rocks were described by the author as occurring in various localities. At the Cloncurry, Cape River, Gilbert, Peak Downs, Black Snake, Kilkwan, and Goaroomjain Diggings these are mica- and hornblende-schists, whilst at the Ravenswood Diggings the rock is a granite with triclinic felspar. The latter, which contains more or less hornblende, the author regarded as of metamorphic origin. The author noticed the connexion between the presence of trappean rocks in these metamorphic areas, and in the Devonian area, and the production of auriferous and cupriferous lodes.

True granites crop out along the eastern coast of Queensland, and these vary much, passing into porphyry and quartz-porphyry, but monoclinic felspar always predominates in them.

The intrusive Trappean rocks, which are regarded as influencing the production of auriferous veinstones in the Devonian and metamorphic rocks, are noticed at considerable length by the author, and consist of pyritous porphyrites and porphyries, pyritous diorites and diabases, chrome-iron serpentines and pyritous felsites; the author considers that this order probably indicates the succession of these rocks in time. The veinstones, he thinks, were probably deposits of mineral matter from the hydrothermal action which preceded, and continued long after the cooling of the traps themselves.

The volcanic rocks, in the author's opinion, have played a most important part in determining the elevation and present physical outline of north-eastern Queensland; they follow the line of greatest elevation on the main watershed at altitudes of from 1500 to 2000 feet above the sea-level. The general arrangement of the other rocks referred to is epitomized by the author as follows:—

"With the exception of the McKinlay ranges, a line drawn parallel with the eastern coast at a distance of 250 miles would include all the Palæozoic, metamorphic, and igneous rocks represented in the colony, both coal-groups lying within the same area.

"The Mesozoic and Cainozoic systems occupy the surface area to the westward.

"The descent going eastward is first locally a thin capping of 'Desert Sandstone,' next Carboniferous, then Devonian, and possibly Silurian, with patches of metamorphic and granitic rocks interspersed.

"The chief granitic mass extends from Broad Sound to Cape York, with an occasional capping of 'Desert Sandstone.'"

The paper contained numerous analyses of the various rocks, and the fossils have been worked out by Messrs. Etheridge and Carruthers, whose lists and descriptions of them are appended to the paper.

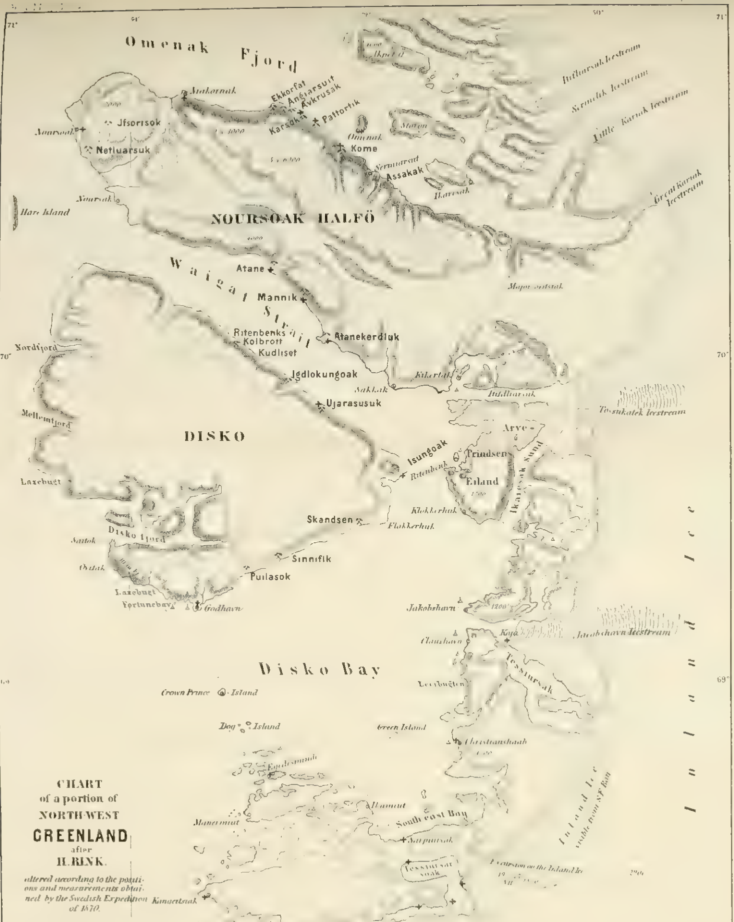
Discussion.—Mr. Etheridge mentioned that, among the fossil Mollusca exhibited from Queensland, there were about eighty species in all, thirty-nine of which were new. About twelve species were also found in the British area, some of them being of common occurrence in both countries. This was especially the case in the Palæozoic rocks, but also prevailed to a considerable extent in those of the Cretaceous period. The same similarity among fossils so widely separated in space was found among the fossil corals of Queensland and those of Europe. It was to be regretted that so many of the fossils are merely casts; but he still thought that they were capable of being properly figured, and the species determined.

Mr. Carruthers had examined the vegetable remains brought over by the author, which were of great importance. Some of those from the Devonian rocks appeared to be identical with species found in North America. From the remains of one of these, which he could not separate from one described by Dr. Dawson, *Leptophlœma rhombicum*, he had been able to reconstruct it in its entirety, of which he exhibited a drawing. The plant was lycopodiaceous, and its remains served to show that erroneous conclusions had been drawn as to the characters presented by the North American specimens, which had been regarded as having a *Sternbergia*-pith. There were specimens also of *Cyclostigma*, of the stipes of ferns, and of a doubtful Calamite. With regard to the supposed *Glossopteris*- and *Tæniopteris*-epochs, which by some had been regarded the one as Palæozoic and the other as Mesozoic, he was not convinced that they could be distinctly separated, but thought rather that they might both belong to different portions of one great period. Systematically the two forms might be very closely related, the venation of the fronds on which the genera are founded occurring in two forms, which by Linnæus had been included in one genus, *Acrostichum*. He thought that neither was of a date earlier than Permian.

Mr. Smyth regretted that so many questions were brought forward in the paper that it was almost impossible to follow the whole of them. The connexion of the gold-bearing reefs with the igneous rocks seemed to him very remarkable. It had in former times been suggested that there was some limitation of auriferous deposits to Palæozoic rocks, and he wished to know whether the author's observations corroborated such a view, which appeared to him problematical. He commented on the value of foreign collections of fossils such as that exhibited, and called attention to the rich stores of that kind preserved in the museum of the Society, which would be found of great assistance by any one studying the geology of Australia.

Mr. Daintree, in reply, stated that in the West Maitland beds *Glossopteris* was found distinctly underlying beds containing *Spirifera* and other distinctly Carboniferous species. He had no doubt of *Glossopteris* being in Queensland a purely palæolithic form. He had been unable to trace any igneous action whatever over the whole of the cretaceous plains to the westward; and the absence of igneous or metamorphic rocks was further proved by the natives having to obtain the materials for their tomahawks by exchange from those nearer the coast. In the proximity of the dykes he had not found any signs of alteration of structure; but the occurrence of gold in the Devonian area was, according to his experience, limited to the close neighbourhood of the dykes.

The Chairman remarked on the Desert Sandstone, and pointed out that, though apparently of such importance, the amount of geological time it represented was but small. The changes, however, of which it bore evidence since Miocene times, were enough to strike the mind with astonishment, and to convey some idea of the great variations in the physical features of the surface of the world, even within the period during which possibly the human race had existed.



Omenak Fjord
Ekkorfat
Angiarsuit
Avkrusak
Karsok
Pattorfik
Jfsorisok
Netluarsuk
Kome
Assakak
Hare Island
NOURSOAK HALFÖ
Little Karsak Icestream
Great Karsak Icestream
Waigat Strait
Atane
Mannik
Ritenbenks
Kolbrott
Kudliset
Atanekerdluk
Nordfjord
Igdlokungoak
Ujarasusuk
Mellemfjord
DISKO
Arve
Isungoak
Prindsens
Eiland
Laxebugt
Skandsen
Disko fjord
Sinnifik
Puilasok
Laxebugt
Fortunebay
Godhavn
Jakobshavn
Jakobshavn Icestream
Claushavn
Disko Bay
Crown Prince Island
Dog Island
Green Island
South east Bay
Inland Ice
CHART
of a portion of
NORTH-WEST
GREENLAND
after
H. RINK.
altered according to the positions and measurements obtained by the Swedish Expedition of 1870.
+ Position determined
⚒ Locality for Plant-Fossils.
Localities where dredging was carried on by Dr Oberg
71°
70°
69°
68

THE

GEOLOGICAL MAGAZINE.

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ORIGINAL ARTICLES.

I.—Account of an Expedition to Greenland in the year 1870.

By Prof. A. E. Nordenskiöld,

Foreign Correspondent Geol. Soc. Lond., etc., etc., etc.

Part I.

(PLATE VII.)

THE information gained by us during the first three Swedish expeditions to Spitzbergen having, either directly through our own experience, or indirectly through conversation with most of the intelligent and bold whalers and walrus-hunters of Northern Norway, fully confirmed the observations of Scoresby, Phipps, Tschitschagoff, Parry, Buchan, Franklin, Clavering and others, respecting the impossibility of penetrating by ship during the summer through the crowded ice-masses to the north of Spitzbergen, far beyond the 80th degree of latitude, an Arctic Expedition was sent out from Sweden in 1868, having for its object, among other things, to renew during the autumn months the attempt to sail towards the pole from the northern coast of Spitzbergen. I have, in a report[1] of the expedition of 1868, given a brief account of the result of that undertaking, which showed that even at that period of the year, when the water is most free from drift-ice, the polar basin, at least to the north of Europe, and doubtless also to the north of America and Asia, is so full of drift-ice that all possibility of passing through it in a ship is out of the question.

This unsuccessful attempt did not, however, diminish the interest in Sweden for the polar question, but seemed, on the contrary, to excite to new exertions in the same direction. Almost immediately on the return of the expedition (1868), preparations were set on foot in Gothenburg to collect the necessary means for a new polar expedition, the object of which was to proceed during winter from the Seven Islands by sledge towards the Pole, and in less than a year the amount considered necessary for the purpose was collected.

It was our intention to use Greenland Esquimaux dogs for the proposed sledge-journeys. I determined, however, first personally to convince myself of the applicability of these animals as beasts of draught, and of the possibility of obtaining a sufficient number, and

[1] Proceedings of Royal Geogr. Soc., xiii., No. iii., p. 151 (1869).

this gave occasion to the expedition to Greenland, which forms the subject of the present description. But, before specially entering upon this subject, I take the opportunity to offer a few brief observations on the many suggestions that have been made and discussed by geographers concerning the most practicable way of approaching the Pole, and thus explain more in detail the reasons for the choice made by us of the proposed starting-point, plan, etc., of our expedition.

The real polar basin north of the 80th degree may be approached by the following ways:—

1st.—*Way to the east of Spitzbergen.*—Petermann has proposed that an attempt be made to pass, *by ship,* through the broad channel that separates Spitzbergen from Nova Zembla.

Respecting the condition of that sea ("Spitzbergen Sea," Petermann), as regards ice, we are in possession of numerous observations, made partly by older polar travellers, or rather searchers after a north-east passage; partly by the expeditions repeatedly sent to that part by the Russian Government; and lastly by sundry German, English, and especially Norwegian hunting and fishing expeditions of late years. These observations all agree that an unbroken ice-belt extends between these islands, at least as far as the 78th or 79th degree of latitude, leaving, in favourable years only, a broad channel running to 80°, partly along the east coast of Spitzbergen, and partly along the western coast of Nova Zembla.

How difficult it is, east of Spitzbergen, to reach as far as 80°, is evidenced by the circumstance that out of all the many attempts that have been made to sail round Nova Zembla, only one has succeeded, viz., Johannessen's remarkable voyage in the summer of 1870.[1] Norwegian fishermen from the south, though attracted by a rich booty, have never, on the eastern coast of Spitzbergen, reached 80°, and, although one might probably on the western coast reach the Seven Isles every year, the passage round the north-eastern extremity to the Thousand Isles has only once been successfully attempted, and even then with the hazard of being driven by the adjacent ice-fields upon the steep glaciers of the north-east land, and there crushed, as happened in 1864 to three fishing vessels. It is therefore utterly impossible to proceed by ship in this direction, nor does either Nova Zembla, or the eastern coast of Spitzbergen, or the as yet but little known Gillies Land, offer any easily accessible starting-point for sledge-journeys, situated sufficiently north. This course is then hardly to be thought of for a polar expedition with any prospect of success.

2nd.—*The way along the eastern coast of Greenland,* also ardently urged by Petermann. Numerous expeditions—of which only a few have been able to penetrate the ice so as to approach the coast, and only two, viz. Clavering and Sabine's in 1823, and the German polar expedition of 1869–70, reached 75°–76°—have made known that portion of the Arctic Ocean; and we know that the sea here, even at

[1] This was written in December, 1870. The expedition of the last summer seems to me wholly to confirm the result of the older expeditions, but by no means to prove the existence of an open polar sea extending to the Pole.

60° lat., is more impassable than at a corresponding latitude in any other part of the northern hemisphere. A broad, almost always densely-crowded, stream of ice is constantly carried down by the north polar stream, not only along the whole eastern coast of Greenland, but, during a great part of the year, past Cape Farewell a considerable distance into Davis Strait. Among the many empty reasons often adduced for the existence of an open polar basin, this stream is also appealed to, by which it is alleged that the ice in the polar basin must shortly be carried down into the Atlantic. A simple comparison of the extent and velocity of the ice-stream with the area of the polar-basin is sufficient to show the futility of this argument. If we suppose the entire limit of the stream to lie in 5° west longitude from Greenwich, its breadth will be about 200 miles. With a velocity of four miles a day—(the German expedition, 1869–70, after the wreck of the "Hansa," drifted about 600 miles southward in 200 days)—by this process about 100,000 square miles would be removed from the polar basin during June, July, August, and September; that is to say, in the course of the months during which new ice is not forming in the polar basin, an area which does not constitute the tenth part of that basin north of 80°.

The following enumeration of the attempts which have been made to penetrate to the eastern coast of Greenland fully shows the difficulties met with in this part of the polar basin.

1579.[1] Jakob Allday was sent out by the Danish King, Frederick II., to rediscover Greenland, advanced so far as to see the east coast, but returned, as the ice nowhere permitted him to land (Rink).

1588 (1581 Rink, 1578 Graah). Mogens Heinesen was sent to rediscover Greenland for the benefit of Denmark, but returned without having been able to land.

1605. A new Danish expedition was sent out, under Godske Lindenow, and reached a harbour, probably on the south-western part of the coast (Rink).

1607. Carsten Richardsen was sent out to Greenland, but was everywhere prevented by ice from landing.

1607. H. Hudson reaches the eastern coast of Greenland, at $73\frac{1}{2}$° latitude.

1652—54. Three expeditions, provided by H. Möller, and commanded by David Danel. These expeditions sailed along a considerable part of the west coast of Greenland, and had *nearly, but only nearly*, succeeded in landing on the east coast.

1670. A Danish expedition, sent out under Otto Axelsen. The expedition returned without accomplishing its object; hindered, in all probability by drift-ice from landing on the eastern coast.

[1] In this account, in which I have principally confined myself to the last generally known Danish expeditions, because their especial object was to reach East Greenland, I have followed partly W. A. Graah, *Undersögelses-Reise til Östkysten af Grönland. Kjöbenhafn*, 1832, and partly H. Rink, whose excellent work, richly stored with observations, "*Grönland, geographisk och statistisk beskrevet*," 3 Delar. *Kjöbenhafn*, 1852–1857, I have frequently made use of in this account.

1671. A new expedition, sent out under the same person. The expedition never returned, being most probably wrecked amidst the drifting ice.

1751—1753. Peder Olsen Vallöes' remarkable expedition in an "umiak" (Greenlandish boat rowed by women) from the west coast round Cape Farewell, in which he, in spite of a thousand difficulties amidst the crowded ice-masses, succeeded in reaching 60° 28′.

1786—1787. Expeditions under Lövenörn, Egede, and Rothe endeavoured to penetrate from Iceland to east coast of Greenland, but could only see its lofty hills at a distance. The land being rendered quite inaccessible by ice.

1819. Scoresby succeeded in reaching the east coast of Greenland, which during his many years of whaling-voyages he had always previously found completely blockaded by ice.

1823. Sabine and Clavering sail from Spitzbergen to the eastern coast of Greenland, which they reach in latitude 74°—75°.

1828—1831. Graah's journey round Cape Farewell, in a "kone-boad." He succeeded with great difficulty in reaching 65° 15′ N.L. His account of his journey, which Dr. Petermann adduces as evidence that the east coast is free from ice, gives us clearly to understand, that it is only under very unusually favourable circumstances that a ship can make its way in these parts through the packed ice-masses.

1868. Dr. Petermann's expedition, under Capt. Koldewey, strenuously but vainly endeavoured to approach the eastern coast of Greenland.

1868. The Scottish whaler *David Gray* finds the east coast of Greenland free from ice at 74° N.L.

1868. The Swedish Polar expedition endeavours twice to approach the eastern coast of Greenland to the north of the 78th degree, but was, in the longitude of Greenwich, hindered by impenetrable masses of ice from proceeding farther towards the east.

1869. The second German Polar expedition under Koldewey and Hegemann. One ship lost in 70° 50′ N.L. among the ice-masses on the eastern coast, and the brave crew borne down among the densely packed ice-masses to the southern extremity of Greenland. The other ship reaches land at 75°—76°, but finds the ocean to the north completely blockaded by ice.

When we consider that all the Danish expeditions were undertaken with the expectation of recovering almost a northern Eldorado, which (as they imagined) had formerly been every year sailed over in frail Vikings' vessels,—and that these expeditions were conducted by efficient seamen well practised in their work by expeditions to Iceland and Finmark, at a time when not only Dutchmen and Englishmen, but also the Danes themselves, in other parts of the polar regions, had penetrated so far that even up to the present time in many places no farther advance has been made,—their repeated failures must surely prove, not only the impossibility of reaching the Pole by this course, but also the unfitness of East Greenland as the starting-point for such expeditions, whether the object be to attain the Pole on board ship, or in a boat, or by dogs, or any other method of conveyance.

3rd. *The way through Behring's-strait,* proposed by Gustave Lambert. The waters north of Behring's-strait are one of the least known parts of the Arctic Ocean; it is, however, known that the sailor is there met by impassable ice-masses in a latitude where to the north of Europe scarcely any signs of ice are met with, even in the midst of winter, and that only a most unusual occurrence made it once possible for a whaler in these parts to reach 73° 30′ N.L. To choose this course for an expedition towards the Pole would therefore be contrary to all reason; and when the proposer of this plan, in a public lecture, stated that it might be confidently expected in France that the Tricolour would be waving at the North Pole of the Earth by the time the news of the expedition's arrival at the Sandwich Isles should reach Paris, it showed but a sorry acquaintance with the state of the Polar Seas—unless, indeed, we are to consider the words as a mere rhetorical phrase. Nevertheless, it may be adduced as one among various reasons that might be given for an Arctic (not Polar) expedition to these parts, that here, in the narrow strait between the old and new worlds, so many circumstances are as yet unexplored in natural history, geology, ethnography, and geography, that such an expedition, even if unable to proceed to the 80th degree, would probably furnish important scientific results, and greatly extend our knowledge of the wonderful kingdom of nature than a polar expedition following any other of the possible routes (over Spitzbergen or Smith's Sound), even if that expedition were crowned with perfect success. But if an expedition to Behring's Straits is to be of any value, it is an indispensable condition that it be manned, not with curious and adventurous tourists, but with men fully competent for scientific research.

4th. *The way over Spitzbergen,* and

5th, *that over Smith's Sound.*—These routes have been recommended by English, American, and Swedish polar voyagers, and as, in my opinion, it is only by choosing one or other of them as a starting-point that any prospect of attaining the proposed end can be entertained, and as moreover the advantages they each offer are in general of the same kind, I shall accompany this reference to them by a few short remarks on them in common.

The name "Polynia," imported from Siberia, has unfortunately produced a very considerable confusion of ideas in geographical science. In the first place, Polynia has been erroneously interpreted as a sea free from ice and accessible to ships, whereas, on the contrary, that word signifies sometimes a sea covered with broken ice (but not on that account navigable), sometimes a greater or smaller opening in an ice-field produced by accidental circumstances. Again, contrary to all real experience, the whole polar basin has been declared navigable simply because the famous Russian polar explorer, Wrangel, found a Polynia some miles north of the northern coast of Siberia, in about the latitude of North Cape, and Stewart, in an American polar expedition, (as we now know through Petersen's more critical description,) gave a very exaggerated account of a larger opening in the ice in a part of the Polar Sea situated to the north of Smith's Sound, which nevertheless was not accessible even to a boat from the adjoining Rensselaer Harbour. In the observations of Wrangel, Kane, and Morton, I cannot discover any signs of a reason for assuming the existence of an open Polar Sea. It is, however, of importance in fitting out such expeditions as endeavour to approach the Pole on the ice by sledge, inasmuch as it shows that one cannot, even in the midst of winter, reckon on an unbroken field of ice. The travellers in these sledge-journeys will thus be obliged to take with them a boat of sufficient dimensions to contain the whole company, and so light as not too much to limit the number of days for which they can carry provisions. This circumstance renders it necessary to choose for starting-point an easily accessible spot situated as far north as possible; and a glance at the terrestrial globe shows us that only two points can be thought of for such a purpose, viz. the northern coast of Spitzbergen, and the most northerly part of the west coast of Greenland, or perhaps rather the corresponding part, Grinnel-land, situated on the other side of the narrow Smith's Sound. Each of these routes has its advantages. Spitzbergen lies near Europe, and is accessible all the year up to a latitude somewhat exceeding 80°, and one can almost every year sail over a sea free from ice even north of the Seven Islands.

An expedition, with the north coast of Spitzbergen for its base, might then choose as its starting-point a spot situated very considerably nearer the Pole, than if it set out from Smith's Sound, where it is hardly possible to reckon on penetrating by ship much beyond 78°. This advantage on the side of Spitzbergen is however, in a great measure, if not wholly, counterbalanced by the circumstance, that in proceeding from Smith's Sound one advances for a considerable distance with land alongside, an immense advantage in the establishment of depots, etc., as also, though perhaps in a less degree, by the fact that the coasts at Smith's Sound are inhabited by an Esquimaux tribe, which, although now since its contact with Europeans thinned and dying out, can nevertheless, in spite of its helplessness, during the long and dangerous winter night, offer an assistance to an expedition that is to pass the winter there, which can hardly be compensated by any outfit from home, though designed with all the aids of civilization. For an expedition that can command unlimited pecuniary means, that is furnished with provisions for several years, and can afford to lose one or two of its ships in attempting to advance to winter quarters north of Rensselaer Harbour, I conceive, therefore, that this route may be preferable.[1] But with

[1] An expedition sent from America or England over Smith's Sound ought undoubtedly to have at its disposal several ships provided with steam, one large vessel, which should never proceed to parts from which it cannot with safety return, and several smaller (60 to 100 tons), which at different times and by different routes should endeavour separately to advance through the ice, secure, in case of wreck, of

the means at the disposal of the Swedish expedition, Spitzbergen ought to be chosen as the starting-point, more especially as we are thus enabled to lay the last stone upon a series of researches carried on during the course of several years concerning the physical condition and natural history of Spitzbergen.

These are the considerations to which most weight has been assigned in devising the plan of the Swedish expedition, which is to proceed to the north in 1872. It is intended that the expedition shall consist of three or four scientific men (among whom are to be a natural philosopher and a zoologist, the latter for the study of marine animal life during the winter), with the necessary crew, and that it shall pass the winter in a cot erected for the purpose, if possible, on the Seven Isles, with a magnetic observatory, storehouse, etc. From this point the expedition is to make during the latter part of the winter sledge-journeys northward, and, if the time admit of it, eastward toward Gillies Land. But it will be time to communicate further notices of this proposed polar colony, its composition, preparations, etc., when it is in possession of that of which it is as yet destitute—the interest of a *fait accompli.* I therefore proceed to a description of this summer's journey to Greenland, undertaken, as has been already mentioned, as preparatory to the polar expedition itself, occupying myself less with our own adventures, which for the public in general are but of little interest, than with giving an account of the scientific results obtained.

Greenland is not only the first land discovered in the new world, but it is the oldest European colony on the other side of the Atlantic, which, ever since its first planting, near a thousand years ago by Norse-Icelandic Vikings, has constantly, though for a time forgotten, belonged to the same mother-land; and it is honourable to that mother-land that the wild tribes, which for a while after the foundation of the colony came in contact with the colonists, have not been brought into that degraded condition indicative of speedily impending extinction which is the case with the original inhabitants of many other lands visited by European civilization. The Greenlanders, on the contrary, seem to be in a fair way of development to a small peculiar nationality, which is in a certain degree acquiring the culture of the Caucasian race. Already almost every West-Greenlander can read and write; a number of small works, not only on religion, but on history, geography, and natural history, are printed in Greenlandish; and a Greenlandish newspaper, which in respect of typography may vie with most of the European popular newspapers, is printed at Godthaab.

Greenland, as is known, belongs to Denmark, but is not governed by the ordinary state authorities, but by a Trading Directory (origin-

the possibility of returning to the depot-ship. Should any of these small vessels succeed in reaching an anchoring-place, e.g. in 81° lat., the success of the expedition would be much better secured than if the large vessel wintered in say 79° lat.; and if one of the small vessels should be lost, the loss is comparatively trifling. Such an event need not be accompanied by loss of life.

ally a private trading company), which has for its object to trade with the inhabitants for the benefit of the Danish state, that is to say, to buy up at certain, often merely nominal prices, train oil, skins, down, and other of Greenland's hunting and fishing productions, and to supply the Greenlanders with European wares instead, many of which, as for example firearms, ammunition, coffee, sugar, bread, have long been necessaries to the inhabitants. The chief management of the Greenland trade is confided partly to certain Directors residing at Copenhagen, partly to two resident Inspectors immediately appointed by the ministry. Under these are at present eleven Colonial Governors resident in Greenland (Julianshaab, Fredrikshaab, Godthaab, Sukkertoppen, Holsteinsborg, in the inspectorate of South Greenland; and Godhavn, Egedesminde, Jakobshavn, Ritenbenk, Omenak, Upernivik, in the inspectorate of North Greenland). To aid the Colonial Governors, they have "assistants" and "volunteers" (aspirants to the place of colonial governor), as also "emissaries" ("utliggare"). These last-mentioned offices are sometimes given to Greenlanders, the others exclusively to Danes. There are also in every colony some Danish artisans.

The shipping business in Greenland is carried on by the Greenland trade in the Company's own ships, which, as the cabins are fitted up to receive three or four passengers, offer a cheap though slow passage. The time of starting from Copenhagen is from the month of April to June, and all the vessels, unless hindered by ice, as sometimes happens in the harbours of South Greenland, return in the autumn, usually in the middle or at the latter end of September. A few of the ships, that have sailed earliest, return however in July, so as to make a second journey during the summer. The passage out usually occupies five to eight, the return voyage three to six weeks.

In the veteran ship of the company, the brig "Hvalfisken," commanded by Captain Sejstrup, the Swedish expedition departed from Copenhagen on the 15th of May, 1870. My original intention was only to make a short visit to Greenland, in order to take some steps preparatory to the contemplated polar expedition. I was however but little inclined to consecrate the whole summer to that purpose, and determined accordingly, with the permission of one of the most liberal patrons both of the preceding and the coming expeditions, Mr. Oscar Dickson, to expand the tour to Greenland into a little unpretending expedition, having for its object not only to make preparations for the future polar expedition, but also to carry on such researches in natural history, geology and geography as might be of importance in arranging the collections and observations made at Spitzbergen. For this reason the number of members of the new expedition was increased to four, including, besides myself, Dr. Sv. Berggren from Lund, also Dr. P. Öberg and Dr. Th. Nordström from Upsala.

Our plan was, on arriving in Greenland, to set in order and completely man, either with Danes or natives, two whale-boats. With one of these Dr. Nordström[1] and I were to penetrate into Auleitsi-

[1] During the voyage over Dr. Nordström caught a cold, which fortunately was not

vikfjord, never previously visited by European, and up to the present time not mapped; afterwards, for the purpose of geographical investigations, and especially for collecting fossil plants, we were to go round the shores of the Waigat, Disko Bay and Omenakfjord. Dr. Öberg and Dr. Berggren were, on the other hand, to travel in their boat round Disko Bay, and collect contributions to its flora and fauna. Öberg was for this purpose furnished with abundant zoological apparatus.

The undertaking excited, as usual, much interest at home. His Swedish Majesty's fleet, among other things, provided the expedition with the necessary apparatus for sounding, and the Royal Academy of Science in Stockholm lent chronometers, astronomical instruments, etc.

In the earlier times of communication with Greenland, the passage out was united with great difficulties, owing to the quantities of drifting ice met with in doubling Cape Farewell; experience however afterwards showed that this inconvenience might be almost entirely got rid of by entering Davis Strait between $57\frac{1}{2}°$ and $58\frac{1}{2}°$ N.L., that is, at least 1° or 2° south of that dangerous headland, which few of the Greenland travellers of our time have ever seen, and by this means one may in the spring sail up to North Greenland from Denmark, not indeed without now and then fetching a compass on account of the ice, but without being exposed to any very much greater risk than in other channels free from ice. On the present occasion also the "Hvalfisk" made that (by long experience) approved circuit, and, after four weeks' voyage, reached the longitude of Cape Farewell. Here we were exposed to a very violent storm, during which the ship was obliged to lie to nearly a fortnight, afterwards north of 60° lat. we were further obliged to make a number of delaying circuits, to avoid the ice driven by the storm to the mouth of the Strait. In consequence of this, our voyage out occupied about eight weeks. In fact, we landed on the 2nd of July at Godhavn, originally a Danish whalers' station, now, since the Danish whale-fisheries have been discontinued, one of the minor Danish colonies in that tract, but still, in consequence of its central position and of old custom, the seat of the principal magistracy in North Greenland, the *Inspectorate of* North Greenland.

Hudson, and other veteran mariners of the Arctic seas, mention the variety of colours that distinguish the water in certain parts of the polar sea, which are frequently so sharply distinguished that a ship may sail with the one side in blue and the other in greyish-green water. It was at first supposed that these colours were indications of different currents—the green of the Arctic, the blue of the Gulf-stream. Later, Scoresby affirmed that the phenomenon arose from the presence of innumerable organisms, which he seems to have considered as crustacea, in the water. This observation has since

of long duration, but hindered him from taking part, as had been intended, in the journey on the ice. His place was supplied by Berggren, who accordingly accompanied me to Auleitsivik.

been continued, partly by the former Swedish arctic expedition, and partly by Dr. Brown,[1] during the voyages made by him in the arctic seas as Surgeon in a whaler, and as a member of Whymper's expedition. We also endeavoured to divert the tedious monotony of the voyage by observations on this phenomenon.

The sea-water in the neighbourhood of Spitzbergen is marked by two sharply distinguished colours—greyish-green and fine indigo blue. In the Greenland seas we also find water with a very decided shade of brown. These colours are seen most pure if one looks vertically down from the ship to the surface of the water through a somewhat long pipe. The green, or rather grey-green, water is generally met with in the neighbourhood of ice (whence it was supposed to arise from the arctic current); the blue where the water is free from ice; the brown, as far as I am aware, chiefly in that part of Davis Strait which is situated in front of "Fiskernaes." When specimens of the water are taken up in an uncoloured glass, it appears perfectly clear and colourless, nor can one with the naked eye discover any organisms to account for the colour. But if, when the velocity of the ship allows of it (i.e. when the ship makes from one to three knots an hour), a fine insect net be towed behind the ship, it will soon, in the green and brown water, be found covered with a film of in the former case green, in the latter case brown slime, of organic origin, and evidently the real cause of the abnormal colour of the sea-water. Just in these parts may be found swarms of small crustacea, which live upon this slime, and in their turn, directly or indirectly, become the food of larger marine animals. The blue water on the contrary, at least in these seas, deposits no slime upon the insect-net, and is far less frequented by Crustacea, Annelides, etc., than the green. Thus, as Brown, in the article above referred to, remarks, the presence of this slime, inconsiderable as it is, but spread over hundreds of thousands of square miles, is a condition necessary for the subsistence, not only of the swarms of birds that frequent the northern seas, but also of that giant of the animal creation, the whale, and all branches of industry dependent on whale-fisheries.

Of these remarkable organisms Dr. Öberg collected specimens when possible, during the voyage, which it is intended hereafter to submit to a careful scientific examination, in conjunction with similar specimens from preceding expeditions. Here we need only mention that the slime itself in each particular place is formed only of a few species of Diatomacea, often so large that after drying the mass, the siliceous frustules may be discerned with the naked eye; but on the other hand, different parts of the ocean exhibit entirely different forms, so that, for example, the green slime in one place has sometimes not a single species identical with that in another. A long continued collection will therefore be required to explain this scanty but, nevertheless, so remarkable and, we may safely say, important flora of the ocean's surface.

In Copenhagen our expedition was most kindly received by the

[1] A very interesting essay on this subject has been published by Dr. Brown: *The Farmer*, Jan. 1, 1868, p. 16.

Board of Directors of the Greenland trade, who not only granted us the same favourable terms for our voyage out in the "Trade's" ships which they grant to their own officers, but also gave us an unlimited letter of credit on their various stations, together with a letter patent of recommendation to their Governors, who also everywhere received us in the most hospitable manner, and assisted us in getting boats, provisions, and particularly crews. The obtaining of crews in Greenland is an especially difficult matter. A Greenlander's desire to earn is, in general, confined to the day's necessities; his unwillingness to undertake any service is particularly great; and lastly, he is so attached to his home, his wife and his children, and, if not provided with these, to his in general very ill-treated dogs, that already, after a fortnight's separation, he is quite homesick. This is equally true of the thoroughbred Greenlander and of the mixed races, which form a considerable portion of the population of the colony. The Danish artisans in Greenland, in fact, often marry natives. The children in these cases are said seldom to learn their father's language, but in general only Greenlandish, which language—difficult as it is to elder persons consciously or unconsciously accustomed to totally different linguistic rules,—perhaps on account of the abundance of expressions for the objects and actions amid which the children grow up—is caught by them with such ease and partiality that even pure European parents find it difficult to get their children to speak their real mother-tongue. Moreover, the necessity of earning their bread soon compels these children to have recourse to purely Greenlandish sources of gain, and to adopt Greenlandish customs. The child of a Danish father and a Greenlandish or mixed-race mother thus becomes, both in language and manners, a complete Greenlander; perhaps, however, a little less given to think *only* of the day actually passing, and therefore with a somewhat better prospect of maintaining himself than the more careless original natives.

Thus, while European customs of society and European language are almost powerless when in competition with those of Greenland, the European features and form of the body are preserved, almost without any alteration. The mixed-race, therefore, which meets us in almost every colony, is distinguished by a tall figure, often with light hair, and not unfrequently a very handsome person, if not too completely spoiled by Greenlandish dirt.

European features seem to have something more attractive to a Greenlander's sense of the beautiful than the flat form of countenance common among themselves, and thus many skin-clad canoe-men are descended, through several generations, from purely European fathers, married with women of mixed race; and there is, therefore, more Danish, Norwegian, Swedish, or English, than Greenlandish blood in their veins. Anything of that readiness to face danger and seek adventures, which, inherited from the wild piratic and chivalrous ages, forms a feature in our national character, will be looked for in vain in the descendants of Europeans in Greenland; and the European with Greenlandish blood in his veins is as timid and fainthearted as the Greenlander himself. Real service, in the European sense of the word, he will seldom bear long. He is unwilling, for any length of time, to leave his turf-house, his wife, children, and dogs. He avoids every danger to which his fishing does not drive him—nay, not only danger, but what he vainly imagines to be such; as, for example, a longer sail in a capacious and safe whale-fishing boat.

A Greenlander cannot now, at least in winter, dispense with several articles of food imported from Europe, e.g. bread and coffee, but he can never spare sufficient to purchase at once enough even for a week. He is accordingly obliged to reside so near a Danish trading-station (colony or depot) as to be able daily to barter the train and skin of the captured seal for bread, coffee, sugar, etc. The Greenlanders' winter dwellings are, therefore, seldom situated far from the trading-station, but in general crowded together in its immediate neighbourhood. But a Greenlander, who is active and able to hunt, is glad to leave his close hut in the summer, and betake himself, together with the women and children of his household, to a fishing or hunting district, at a distance of several dozen miles, where the family settles in a summer tent made of reindeer hides, to live for a time exclusively on the produce of the land.

On this account, there is in most of the colonies, during the summer, a dearth of men, and especially of such as are able and willing to undertake a longer journey in a whaling-boat. Immediately on our arrival at Godhavn we experienced this, finding it utterly impossible here to get together sufficient crews to man the two whaling-boats indispensably necessary for us. After more than a week's vain parleying, we were, therefore, glad to avail ourselves of the opportunity offered by one of the Trade's vessels of a passage for ourselves and our apparatus (the zoologists' chests, lines, dredges, etc., alone loaded a couple of boats) to Egedesminde, where we were assured we should meet with less difficulty.

We arrived at Egedesminde, a colony situated on the southern side of Disko Bay, after scarce half a day's voyage, and, thanks to the assistance given us by the hospitable governor of the place, Mr. Bollbroe, we found ourselves, within a few hours after our arrival, in a condition to begin our summer's work in earnest. One whaling-boat was purchased, and another was borrowed of Bollbroe, who also procured the crews necessary for manning the boats.

Dr. Öberg remained with one boat, in the neighbourhood of Egedesminde, for the purpose of dredging, and other zoological researches. Dr. Berggren, Dr. Nordström, and I proceeded with the other boat southward, past Manermiut and Kangaitsiak, to the most northerly of the long, narrow, almost river-like fjords, which penetrate far into the land between Egedesminde and Holsteinsborg. We left Egedesminde on the 12th of July, in the afternoon.

We took up our night-quarter, the 12th of July, at Manermiut, the 13th at Kangaitsiak, the 14th, 15th, and 16th on islands in Auleitsivik. On the 17th we at length arrived at the nearest object of our voyage, the northern side of the glacier that shoots out from the inland ice, that occupies the bottom of the northern arm of Auleitsivikfjord, that is to say, the spot selected as the starting-point for our journey over the ice.

The tract through which we passed, like the whole west coast of Greenland south of the basalt region, bears a strong resemblance to the Scandinavian peninsula, and that resemblance is not the result of any accident, but of a similar geological formation, and a similar geological history. The surface of Greenland, like that of Scandinavia, is for the most part occupied by stratified crystalline rock (gneiss, hornblende-schist, hornblende-gneiss, mica-schist, etc.), crossed by dykes and veins of granite, which even bear the same peculiar minerals which distinguish the Scandinavian granite-veins; and, as in the case of our mountains, the mountains of these regions have once been covered with glaciers, which have left unmistakable marks of their presence in the boulders, which are met with scattered high up on the sides of the mountains, in the rounding off, in the polishing and grooving of the surface, and in the deep fjords, evidently scooped out by glaciers, which distinguish both Scandinavia's and Greenland's western coasts. There is, however, this difference, that whereas the glacial period of Scandinavia belongs to an age long past, that of Greenland, though it is receding,[1] still continues. While, in fact, numberless indications show that the inland-ice has in ancient times covered even the skerries round the coast, these are now so free from ice that a traveller in most places has to advance several miles into the country before reaching the border of the present inland-ice. It is at least certain that wherever any one hitherto has penetrated into the land, he has met with its border,[2] and in all instances has seen it from some neighbouring mountain-top, rising inwards with a gradual and regular ascent, till it levels undistinguishably hill and dale beneath its frozen covering, like the waves of a vast ocean.

Of this inland-ice the natives entertain a superstitious fear, an awe or prejudice, which has, in some degree, communicated itself to such Europeans as have long resided in Greenland. It is thus only that we can explain the circumstance, that in the whole thousand years during which Greenland has been known, so few efforts have been made to pass over the ice farther into the country. There are many reasons for believing that the inland-ice merely forms a continuous ice-frame, running parallel with the coast, and surrounding a land free from ice, perhaps even in its southern parts woody, which might perhaps be of no small economical importance to the rest of Greenland. The only serious attempt that has hitherto been made,

[1] Certainly receding, although the inland ice sometimes makes its way to the sea, and thus tracts that have been free from ice are again covered. We have an example of this in the ice-fjord of Jacobshavn, of which more hereafter.

[2] I have, however, met with persons in Greenland who do not consider it as fully proved. that the inland-ice really does form an inner border to the whole of the external coast. Many Danes have resided several years in Greenland without ever having seen the inland-ice.

in the parts of Greenland colonized by Danes,[1] to advance in that direction was made by—

A Danish expedition, fitted out for the purpose in 1728.—A Danish governor, Major Paars, with an armed company, artillery, etc., was that year sent from Denmark to Greenland, and took with him, among other things, also horses, with which it was intended to ride over the mountains, in order to rediscover, by an overland course, the lost (East) Greenland. The horses, however, died, either during the voyage out or shortly after their arrival in the country; and thus this expedition, really magnificent, but prepared in entire ignorance of the real nature of the country, was abandoned.

Dalager's attempt, 1751.—This year the Danish merchant Dalager made an attempt, in about 62° 31′ latitude, to advance in the beginning of September over the inland ice to the east coast. In the first volume of Kranz's "History of Greenland"[2] there is a short description of this journey, interesting, among other reasons, as recording an instance of a glacier, which since Greenland has been an inhabited land has forced its way forward and closed the entrance of a previously open fjord. We find further from that account, that Dalager, partly on foot and partly in a canoe, in company with five natives, reached the border of the inland ice near the bottom of a deep fjord situated north of Fredrikshaab. For two days they continued their journey over the ice, but succeeded during this time in advancing only eight English miles to some mountain summits rising above the ice-field, where a reindeer hunt was undertaken. Dalager would willingly have continued the journey a day or two longer, but was unable to do so, partly because the two pairs of boots taken with them for each person were so cut to pieces by the ice that they walked "as good as barefoot," partly because the cold at night was so severe that their limbs became stiff after a few hours of rest. On the other hand, the route chosen by Dalager seems not to have been interrupted by very many or deep chasms—in the beginning of the journey the surface of the ice was even "as smooth as a street in Copenhagen." Further on however it was extremely rough.

E. Whymper's expedition, 1867.—All that I know about this expedition is, that Mr. Whymper, in company with Dr. R. Brown, three Danes and a Greenlander, endeavoured to make their way

[1] Dr. Hayes's remarkable journey, in October, 1860, over the fields of ice that cover the peninsula between Whale Sound and Kennedy Channel (78° N.L.), was performed, not upon the real inland-ice, but upon a smaller ice-field connected with the inland-ice, like the ice-fields at Noursoak peninsula. The character of the ice here seems to have differed considerably from that of the real inland-ice. Hayes ascended the glacier at Port Foulke, on the 23rd of October, and advanced on foot, the first day 5, the second 30, the third 25 miles, in all 60 English miles. He was here forced to return, in consequence of a storm. The height of the spot where he turned back over the level of the sea was 5000 feet (*The Open Polar Sea*, by Dr. J. J. Hayes, pp. 130–136).

[2] I have not had access to Dalager's original account. "Grönlandske Relationer, indehaaldende Grönländernes Liv og Levnet, deres Skicke og Vedtägter, samt Temperament og Superstitioner, tillige nogle korrte Reflexioner over Missionen, sammenskrevet ved Fredrickshaabs Colonia i Grönland, by Lars Dalager, Merchant.

upon the inland ice with dogs immediately to the north of the ice-fjord at Jacobshavn, but that they turned back again on the second day, after having proceeded only some few miles. The reason of this was probably the unfitness of dogs for such a purpose.

It was originally my intention to renew these attempts, but on conversing in Copenhagen with Messrs. Rink and Olrik, who had formerly been Inspectors in North Greenland, as also with several other persons who had visited Greenland, I found all so unanimous in considering further advance over the inland ice as impossible, that I determined not to risk the whole profit of the summer on an undertaking of the kind beforehand disapproved of by everybody. Nevertheless, I was unwilling entirely to abandon my plan, and determined therefore to make a little attempt at a journey on the inland ice only of a few days' extent.

If the inland ice were not in motion, it is clear that its surface would be as even and unbroken as that of a sand field. But this, as is known, is not the case. The inland ice is in constant motion, advancing slowly, but with different velocity in different places, towards the sea, into which it passes on the west coast of Greenland through eight or ten large and a great many small ice-streams. This movement of the ice gives rise in its turn to huge chasms and clefts, the almost bottomless depths of which close the traveller's way. It is natural that these clefts should occur chiefly where the movement of the ice is most rapid, that is to say, in the neighbourhood of the great ice-streams, but that on the other hand at a greater distance from these the ground will be found more free from cracks. On this account I determined to begin our wanderings on the ice at a point as far distant as possible from the real ice-fjords. I should have preferred one of the deep "Strömfjords (stream-fjords) for this purpose, but as other business intended to be carried out during the short summer did not permit a journey per boat so far southward, I selected instead for my object the northern arm of the above-mentioned Auleitsivikfjord, which is situated 60 miles south of the ice-fjord at Jakobshavn, and 240 miles north of that of Godthaab. The inland ice, it is true, even in Auleitsivikfjord reaches to the bottom of the fjord, but it only forms there a perpendicular glacier, very similar to the glaciers at King's Bay in Spitzbergen, but not any real ice-stream. There was accordingly reason to expect that such fissures and chasms as might here occur would be on a smaller scale.

On the 17th July, in the afternoon, our tent was pitched on the shore north of the steep precipitous edge of the inland ice at Auleitsivikfjord. After having employed the 18th in preparations and a few slight reconnoitrings, we entered on our wandering inwards on the 19th. We set out early in the morning, and first rowed to a little bay situated in the neighbourhood of the spot occupied by our tent, into which several clayey rivers had their embouchures. Here the land assumed a character varied by hill and dale, and further inward was bounded by an ice wall sometimes perpendicular and sometimes rounded, covered with a thin layer of earth and stones, near the edge, only a couple of hundred feet high, but then rising at first rapidly, afterwards more slowly, to a height of several hundred feet. In most places this wall could not possibly be scaled; we however soon succeeded in finding a place where it was cut through by a small cleft, sufficiently deep to afford a possibility of climbing up with the means at our disposal, a sledge, which at need might be used as a ladder, and a line originally 100 fathoms long, but which, proving too heavy a burden, had before our arrival at the first resting-place been reduced one-half. All of us, with the exception of our old and lame boatman, assisted in the by no means easy work of bringing over mountain, hill, and dale, the apparatus of the ice expedition to this spot, and after our dinner's rest, a little further up the ice-wall. Here our followers left us. Only Dr. Berggren, I, and two Greenlanders (Isak and Sisarniak) were to proceed farther. We immediately commenced our march, but did not get very far that day.

The inland ice differs from ordinary glaciers by, among other things, the almost total absence of moraine-formations. The collections of earth, gravel, and stone, with which the ice on the landward edge is covered, are in fact so inconsiderable in comparison with the moraines of even very small glaciers, that they scarcely deserve mention, and no larger, newly formed ridges of gravel running parallel with the edge of the glacier are to be met with, at least in the tract visited by us.

The landward border of the inward ice is however darkened, we can scarcely say covered with earth, and sprinkled with small sharp stones. Here the ice is tolerably smooth, though furrowed by deep clefts at right angles to the border—such as that made use of by us to climb up. But in order not immediately to terrify the Greenlanders by choosing the way over the frightful and dangerous clefts, we determined to abandon this comparatively smooth ground, and at first take a southerly direction parallel with the chasms and afterwards turn to the East. We gained our object by avoiding the chasm, but fell in instead with extremely rough ice. We now understood what the Greenlanders meant, when they endeavoured to dissuade us from the journey on the ice, by sometimes lifting their hands up over their heads, sometimes sinking them down to the ground, accompanied by to us an unintelligible talk. They meant by this to describe the collection of closely heaped pyramids and ridges of ice over which we had now to walk. The inequalities of the ice were, it is true, seldom more than 40 feet high, with an inclination of 25 to 30 degrees. But one does not get on very fast, when one has continually to drag a heavily-laden sledge up so irregular an acclivity, and immediately after to endeavour to get down uninjured, at the risk of getting one's legs broken, when occasionally losing one's footing on the here often very slippery ice in attempting to moderate the speed of the downward rushing sledge. Had we used an ordinary sledge, it would immediately have been broken to pieces, but as the component parts of our sledge were not nailed but tied together, it held together at least for some hours.

Already the next day we perceived the impossibility under such circumstances of dragging with us the 30 days' provision with which we had furnished ourselves, especially as it was evident, that if we we wished to proceed further, we must transform ourselves from draught to pack horses. We therefore determined to leave the sledge and part of the provisions, take the rest on our shoulders and proceed on foot. We now got on quicker, though for a sufficiently long time over ground as bad as before. The ice became gradually smoother, and was broken by large bottomless chasms, which one must either jump over with a heavy load on one's back, in which case woe to him who made a false step, or else make a long circuit to avoid. After two hours' wandering, the region of clefts was passed. We, however, in the course of our journey, very frequently met with portions of similar ground, though none of any very great extent. We were now at a height of more than 800 feet above the level of the sea. Farther inward the surface of the ice, except at the occasionally-recurring regions of clefts, resembled that of a stormy sea suddenly bound in fetters by the cold. The rise inwards was still quite perceptible, though frequently interrupted by shallow valleys, the centres of which were occupied by several lakes or ponds with no apparent outlet, although they received water from innumerable rivers running along the sides of the excavation. These rivers presented in many places not so dangerous though quite as time-wasting a hindrance to our progress as the clefts—with this difference, however, that they did not so often occur, but the circuits to avoid them were so much the longer.

During the whole of our journey on the ice we constantly enjoyed fine weather, frequently there was not a single cloud visible in the whole sky. The warmth was to us, clad as we were, sensible; in the shade, near the ice of course, but little over zero; higher up, in the shade, as much as 7° or 8°; but in the sun 25° to 30° Centig. After sunset the water-pools froze, and the nights were very cold. We had no tent with us, and, although our party consisted of four men, only two ordinary sleeping sacks. These were open at both ends, so that two persons could, though with great difficulty, with their feet opposite to each other, squeeze themselves into one sack. With rough ice for a substratum, the bed was thus so uncomfortable that, after a few hours' sleep, one was awakened by cramp in one's closely contracted joints, and, as there was only a thin tarpaulin between the ice and the sleeping sack, the bed was extremely cold to the side resting on the ice, which the Greenlanders, who turned back before us, described to Dr. Nordström by shivering and shaking throughout their whole bodies. Our nights' rests were, therefore, seldom long; but our midday rests, during which we could bask in a glorious warm sun-bath, were taken on a proportionately more copious scale, whereby I was enabled to take observations both for altitude and longitude.

On the surface of the inland ice we do not meet with any stones at a distance of more than a cable's length from the border; but we find everywhere instead, vertical cylindrical holes, of a foot or two deep, and from a couple of lines to a couple of feet in section, so close one to another that one might in vain seek between them room for one's foot, much less for a sleeping-sack. We had always a system of ice-pipes of this kind as substratum when we rested for the night, and it often happened, in the morning, that the warmth of our bodies had melted so much of the ice, that the sleeping sack touched the water, wherewith the holes were always nearly full. But, as a compensation, wherever we rested, we had only to stretch out our hands to obtain the very finest water to drink.

(*To be continued in our next.*)

II.—Note on the Discovery of the Oldest Known *Trigonia* (*T. Lingonensis*, Dumortier) in Britain.

By Ralph Tate, Assoc. Lin. Soc., F.G.S.

The ironstone of Cleveland is a repository for a number of interesting species of Mollusca, amongst which a *Trigonia* deserves especial notice, representing as it does the oldest form of the genus, and now recorded for the first time as British.

Till within the last few years *Trigonia littorata* was the precursor of one of the most important generic forms of Mesozoic life, but the publication by Dumortier (Etudes Jurassiques du Rhone, p. 275, 1869), of the occurrence of a *Trigonia* (*T. Lingonensis*) in the Marlstone of the Rhone Basin robbed *T. littorata* of its ancient renown.

T. littorata, Phillips, is stated by its describer (Geol. Yorksh. t. 14, f. 11) to be from the Lower Lias Shale, Robin Hood's Bay, and elsewhere in the same work to be from the Alum Shale. The former statement is doubtlessly a clerical error. It is chiefly to be found in the cement stones above the Alum Shale, but it also occurs in the underlying Shale. This position is on an average 200 feet above the ironstone whence *T. Lingonensis* was obtained.

The characters of the fossil are fully displayed, and do not permit a doubt of its generic position; agreeing, moreover, in size and ornamentation, with the type of *T. Lingonensis* from the Basin of the Rhone, it must be quoted under that name.

T. Lingonensis belongs to the Section *Glabræ* as defined by Agassiz, which contains a few Portlandian and Cretaceous species. It is noteworthy that the oldest species of the genus represents the simplest type of ornamentation.

The specimen on which these remarks are based is, however, not the only one of this species in Britain. My friend, Rev. J. F. Blake, informs me by letter April 18, 1872, that a specimen of *Trigonia Lingonensis*—"in fine preservation, better, as far as I remember, even than yours,—is in the York Museum, labelled 'New Trigonia, by Charlesworth, in 1858.' It is from the ironstone, with green grains, at Maroke" (probably from the Upleatham Mines).

Position and Localities. Zone of *Ammonites spinatus.* Lofthouse (?) and Upleatham Mines (York. Mus.).

III.—A. E. Törnebohm's Theory of the Origin of the Swedish Åsar.

By James Geikie, F.R.S.E.,
District Surveyor of the Geological Survey of Scotland.

In the fourth number[1] of the Proceedings of the Geological Society of Stockholm, there is a paper by Mr. Törnebohm, of the Geological Survey of Sweden, which treats of the origin of the famous åsar,—the same geologist has also kindly sent me some further explanation of his views,—a short account of which will, no doubt, be interesting to many readers of the Magazine.

One of the most striking features of the åsar, says Mr. Törnebohm, is their great length—an ås sometimes continuing for more than a hundred English miles. Often beginning in the interior of the country, an ås follows some particular valley down to the low coast-land, across which it passes as a well-defined ridge out to sea. In the environs of the Mälar Lake, where the åsar have all been studied and mapped by the Geological Survey, they are found as a general rule, when occurring at greater heights than 300 feet above the sea-level, to be strictly confined to the valleys. At lower levels they seem, on the contrary, to be tolerably independent of the present configuration of the land.

In the valleys which contain the åsar, detached patches of sand are sometimes found, perching high on the side slopes. These patches, according to Mr. Törnebohm, are the wreck of a great deposit of sand, which at one time filled the valleys from side to side. While the valleys were still filled with this thick bed of sand, rivers began to flow just as they now do, and cut their way down in the sand. The running water carried along with it coarse sand and gravel, and deposited these on the beds of the rivers, which thus became paved with coarser materials. By and by this state of things changed—denudation set to work upon the whole deposit, and removed the fine sand, but had not power to carry away the coarse gravel which had filled up the old river courses. This gravel, therefore, remained behind, and not unfrequently has protected a considerable thickness of underlying sand. The annexed woodcuts, which are taken from Törnebohm's paper, will further illustrate his meaning.

Fig. 1.

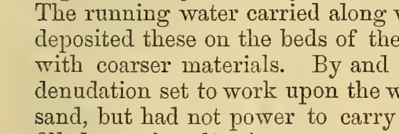


Fig. 2.

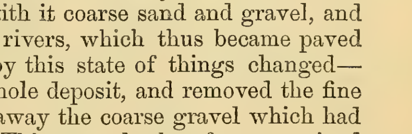


Fig. 1 shows the section of a valley partly filled with sand, *s*, in which is cut the river-bed, paved with coarse sand and gravel, *b*. Fig. 2 represents the aspect of the valley after denudation has removed the greater portion of the sand, patches of which are seen at *a*, *a*. At the bottom of the valley the river gravel rests upon some

[1] Geologiska Föreningens i Stockholm Förhandlingar. Band I. 3 April, 1872.

depth of sand, forming together an ås, *b*. In deep gravel pits opened in the åsar, it would seem that coarse gravel has actually been found to repose upon underlying beds of sand and clay—two sketch-sections being given in the paper to show this arrangement.

The close connexion between the åsar of the valleys and those that strike across the low country, clearly shows that in both districts they must have been formed in the same way. As an example, Mr. Törnebohm cites the åsar that occur in the basin of the Mälar Lake. To apply his explanation to the åsar of that region, it is necessary to suppose the Mälar basin to have been filled up with sand and mud, through which the rivers, coming from the melting *mer de glace*, cut their way to the sea. He then points out that the åsar, in their geographical distribution, show a striking resemblance to river-courses, as will be seen from the accompanying sketch-map, on which the thick black lines represent the åsar.

Fig. 3. Sketch-Map of the Malar Basin, showing the direction of the Åsar.

After the rivers had thus coursed across the broad deposits of sand, which are inferred to have covered so large a part of Sweden, a movement of subsidence ensued, and the Mälar basin became converted into a shallow sea. During this period of depression, the fine sand, which was unprotected by the coarse gravel and shingle of the river-beds, was washed away, and thus the åsar were formed. As the downward movement continued, stratified clay, with Arctic shells, was deposited all round the åsar. By and by the climate became milder, and the present Baltic fauna succeeded the Arctic one. The land began to rise again, and the åsar, being brought nearer to the surface of the sea, formed long shoals or banks, exposed to the action of the waves, which reassorted their outer portions, adding new layers of sand, interstratified with shell marl. The åsar of the lowlands thus became cloaked in a post-glacial covering; to which, and not to the åsar, properly belong those shells of recent Baltic species, which are got near the surface of the ridges.

Mr. Törnebohm's objections to the marine origin of the åsar are: the great length of these remarkable ridges; their common occurrence in narrow valleys; their river-like ramifications; and the fact that they are met with at greater elevations than any undoubted marine drift-deposits. The highest shell-deposits yet seen in Scandinavia are situated not more than 600 feet above the sea-level, and he thinks it unlikely that the sea ever reached a greater height upon the land. The åsar, however, are not limited to that height, for he has traced well-marked åsar up to 1000 feet, and in the mountainous valleys of the north even up to elevations of over 2000 feet. Mr. Törnebohm does not disguise from himself that it is difficult to understand how the denuding force acted, which is supposed to have swept away the fine sand and left the coarse gravel. If marine denudation cleared away the sand and thus gave rise to the åsar of the lowlands, how would he explain the formation of those åsar which reach to heights above 600 feet—that being, as he thinks, the greatest elevation in Sweden attained by the sea in late glacial or post-glacial times?

IV.—Notes on Fossil Sponges.

By Harvey B. Holl, M.D., F.G.S.

I. *Introduction.*—It has been said, with some degree of truth, that our knowledge of the lower forms of life has advanced *pari passu* with the improvements in the construction of microscopes; and no doubt very considerable progress has been made in some departments of investigation within the last few years. In the vegetable kingdom more especially has this been the case; and with respect to animals, the structure of the *Protozoa* has been especially elucidated by able observers, the Spongiadæ chiefly by the labours of Dr. Bowerbank.

Among the lower forms of extinct life, progress has necessarily been slower, especially as regards the sponges, for although new forms have been described from time to time, the group collectively has never received that strict treatment of which it seems capable. Much has yet to be done towards the attainment of a better knowledge of their structure, mode of growth, and variation in form within the limits of the species, and not until this has been accomplished can a right understanding of the true affinities of the several members of the group be arrived at, or any successful attempt made at arrangement of the species and genera.

The little interest which appears to attach to the study of fossil sponges may possibly be due, in great measure, to the difficulties which lie in the way of a rigid determination of the species. This is owing to the inconstancy of the characters on which specific distinctions have been based; and consequently an enormous number of species have been created, the described characters of which are, in many cases, equally applicable to other forms, which are, nevertheless, totally distinct. Hence the subject is involved in a confusion which is rendered still more perplexing by the circumstance, that many of the original types on which the descriptions were based can no longer be traced. The means, therefore, of identifying the species is by no means easy, and in some cases it is impossible to identify them. As an example, we may mention the *Spongites clavellatus*, Mantell, from the Chalk, of which there are two distinct forms, the one composed of a network of inosculating fibres, the other constituted entirely of branched and tuberculated spiculæ. The same may be said of the sponges included in the genera *Chenendopora*, D'Orb., *Cupulospongia*, D'Orb., etc., some of which are spicular, and others fibrous, and yet are precisely similar in their general appearance. In all these cases there are no means of clearing up the doubt, except by reference to the original type.

Like their living analogues, the fossil sponges are liable to great variation in form, and other external and obvious characters; and the remarks of Dr. Bowerbank on this subject are equally applicable to the extinct as to the living species.[1] Yet on external characters alone nearly all the generic and specific distinctions of the fossil sponges have been framed, and very slight variation in external configuration, in the disposition of the oscules, or even in the geological position, has been thought sufficient for the creation of distinct species. Nevertheless, if we except the Foraminifera, there is no class of animals in which the outward characters are less stable, and like these, in conformity with the same low state of organization, there are none that have enjoyed longer range in geological time.

The insufficiency of mere external character for the purpose of differentiating the sponges, and the consequent difficulty experienced in framing specific descriptions precise enough for their identifica-

[1] "There is no class of animals in which the form varies to so great an extent (as the living sponges) according to difference of locality or other circumstances; and even where there is a striking normal form, it is rarely thoroughly developed until the animal has reached its full maturity." *Spongiadæ* (Ray Soc.) vol. i. p. 3. "As a generic character, form is inadmissible, inasmuch as each variety of it is found to prevail indiscriminately in genera differing structurally to the greatest possible extent." *Ibid.* p. 156.

tion, has been long felt. This renders it desirable to discover, in the minuter structure, characters of a more permanent nature. With respect to the living sponges this has indeed been done, more or less successfully, by Dr. Bowerbank. He finds "in the skeleton and in the form and disposition of the spicula, characters which, however Protean the form and colour of the sponge may be, can always be recognized with certainty." Can the same means be made available for the extinct species? Obviously there will be many difficulties in the way, for in the latter we have to deal with the skeleton alone, modified by fossilization; whereas in the former all the structures are in a condition admitting of minute investigation. Nevertheless, very commonly enough of the minute structure can be made out in the fossil to render it a most important means of discriminating the species. The external appearance is all but valueless for this purpose.

II. Prior to the time of D'Orbigny, no attempt had been made to systematize the genera established by Lamoureux, Goldfuss, De Blainville, Michelin, Reuss, and others. M. D'Orbigny, however, conceiving that the fossil sponges had, for the most part, an organization entirely distinct from that of the recent species, divided De Blainville's class AMORPHOZOA into two orders, viz., the *horny* and the *stony* sponges. The former contained but a single genus, *Cliona:* the latter he subdivided into five families, based entirely upon external characters, viz., 1. the *Ocellaridæ;* 2. the *Siphonidæ;* 3. the *Lymnoreidæ;* 4. the *Sparsispongidæ;* and 5. the *Amorphospongidæ.* At the same time he proposed many new genera. These were constituted partly of species which had been distributed by his predecessors among genera established on recent forms by Lamarck and Schweigger, and adopted for fossil species by Dr. Goldfuss.

Pictet,[1] and more lately De Fromentel,[2] have followed D'Orbigny in the view which he took respecting the stony character of the skeleton of the fossil sponges. The *Petrospongidæ* of Pictet, and the *Spongitaria* of the French author, correspond to the "*Amorphozoaires à squelette testacé*" of D'Orbigny. M. Etallon also entertains the same view. He includes among the fossil horny sponges none but the *Clionidæ;* and in speaking of the *Petrospongidæ* observes that the skeleton is solid, "like that of the ZOANTHARIA, and formed, doubtless, in the same manner."[3] In fact nearly all authors, with the exception of MM. Capellini and Pagenstecher,[4] appear to entertain similar views respecting the nature of the skeleton in this large group of fossil species.

D'Orbigny[5] and De Fromentel[6] maintained that the fossil sponges had originally a solid unyielding skeleton. This opinion was partly

[1] Paléont., iv. 2nd ed. [2] E'ponges Fossiles, 1859.

[3] Classification des Spongiaires du Haut Jura, and E'tudes Paléont. sur le Haut Jura, p. 139.

[4] Mikroskopische Untersuchungen ueber den innern Bau einiger fossilen Schwamme Z. W. Z., etc.

[5] "Qu'ils n'ont jamais été cornés, mais que leur tissu à toujours été calcaire et pierreuse." Cours Elementaire de Paléontologie, tom. ii. p. 208.

[6] *l. c.*, p. 5.

based on the supposition that they would not otherwise have escaped compression, and partly on the circumstance that POLYZOA, *Serpulæ, Ostreidæ,* etc., frequently found attached parasitically to the surface of the sponge have been observed to exhibit the worn appearance produced by the rolling of hard bodies on the sea-bed. Moreover, they say that compressed specimens show more or less distinctly the signs of fracture. But while this may be true of some of those sponges that had a solid siliceous framework, it certainly is not generally the case, and examples of *Hippalimus, Ischadites, Mortieria,* and many other sponges more or less distorted by compression, are sufficiently abundant. That they should not—especially the cup-shaped sponges—be more often compressed than they are may, perhaps, be a matter of surprise. But this is probably due to the circumstance that the fine muddy sediment in which they were entombed had so insinuated itself into the interspaces of the sponge as to afford an equal amount of support on all sides.[1] Moreover, some further explanation will suggest itself when speaking of the sponges of Farringdon, and the manner in which fossilization of the sponge appears to have often taken place.

Whether Polyzoa and other parasites are really more frequent on the fossil than on the recent sponge is a question I am not prepared to answer. But M. De Fromentel is certainly not correct in saying that they never occur upon recent sponges; and very frequently the adhesion of the parasite to the fossil sponge is more apparent than real, being produced solely by the cementing influence of fossilization, and by the nature of the matrix in which they are embedded. In any case, unless the Polyzoa grew upon dead individuals, the nature of the skeleton could have had no influence upon the parasite, as, whatever it may have been, it was equally invested by the sarcode of the animal. That the Serpulæ and Ostreidæ sometimes became attached to the sponge while living is apparent from their having become partially embedded in the sponge tissue which has grown over them; but it is so also with recent sponges: and as regards the worn appearance of the parasites and other foreign bodies occasionally found attached to the sponge, it is quite possible that they may have undergone attrition before they became adherent; and, moreover, the fossil itself may have been derived from pre-existing deposits, as were the Oolitic forms found in the gravels of Farringdon.

But there is, in fact, no real ground for assuming with D'Orbigny and others, that the skeleton of the fossil sponges was necessarily

[1] The compression often observed in fossils, especially those of the older rocks, is probably due to the squeezing to which they have been subjected in the change of position and contortion of the beds in which they occur, rather than to the dead weight of the superimposed sediment. It is now well known that Starfish and other soft animals, even at the great depths of mid-ocean, are not compressed, owing to the pressure being applied equally on all parts. Prof. Sars dredged sponges, actinozoa, true molluscs and worms at a depth of 300 fathoms; and the Swedish deep-sea dredgings, in the expedition to Spitzbergen, brought up crustacea, mollusca, and annelids, at depths of from 6000 to 8400 feet. Quoted in *Intellectual Observer* for December, 1866, p. 400, from *Annals of Nat. History.*

always solid and resisting, like that of the recent *Dactylocalyx*, Stutch., the *Farrea* of Bowerb., etc. Many of the siliceous sponges no doubt were so; but as regards the calcareous ones it may be observed that among recent species, according to Bowerbank, "Carbonate of lime, as an element of the skeleton, is known only in the form of spicula."[1] In some cases, as will be shown hereafter, the fibres or twigs were originally complex, formed of bundles of spicula, like the twigs in many of the recent species, and were afterwards consolidated more or less completely by the fossilizing process. But there is no evidence that in others it may not have been keratose, either with or without the accessory spicula. Some of our recent horny sponges are not less resistant than the solid siliceous fibrous species, and are certainly less friable. In the fossil, however, the horny fibre is replaced by silica, lime, or iron. That the tissue in the fossil is not identical with that of the original sponge may be inferred from the circumstance that we commonly find all the sponges from one locality, or one deposit, in the same mineral condition. Thus, all those from the Carboniferous Limestone of the Great Orme's Head are silicified; but so also are the associated Zoophytes, Conchifera, and Gasteropods, etc. All the sponges from the Farringdon Green-sand are calcareous, while those of Warminster are all siliceous. The sponges of the *English* Oolite are all calcareous: those of the Chalk are either silicified, or else in the state of moulds or casts, the walls of which are stained with peroxide of iron.[2]

It has been thought that the iron-staining of the moulds and their refilling with pyrites renders it probable that in the original sponge the fibre was keratose. That in the horny sponges, pyritous casts may be more frequent than in the others is highly probable, but the amount of sulphur in the keratose is far too small to enter into combination with all the iron in the cast in accordance with the theory implied; and assuming that the original skeleton of the sponge was keratose, there is no reason to suppose that the mould would not be refilled in harmony with a general law, *i.e.*, the cast was siliceous when deposited from water holding in solution silica rendered soluble by the presence of lime and alkalies; calcareous from waters holding lime in solution by the aid of an excess of carbonic acid; iron in other cases, and even bisulphuret of lead has been found replacing carbonaceous matter in the plant remains of the Lias of Dunraven.[3] The manner in which the mould is refilled with silica was precisely similar to that by which it is made to replace the carbonate of lime in the tests of the Mountain limestone mollusca of the Great Orme's Head, the Portland rocks of Tisbury, or the Green-sand of Blackdown. The Ostreidæ and Serpulæ, and other parasites

[1] *l. c.* p. 154.

[2] Both *Ischadites* and *Ptylospongia* occurred to Eichwald sometimes calcified, and sometimes converted into bisulphuret of iron, more or less peroxidized. His *Manon deforme*, from Gherikoff, was silicified, while the examples of the same species from the environs of Poulkowa were all calcified. *Lethæa Rossica*, p. 339. *Ischadites Kœnigii* occurs in our British Upper Silurian rocks, both as a calcareous and as a pyritized fossil.

[3] De la Beche, Mem. Geol. Surv., vol. i., p. 273.

attached to the surface of the Warminster sponges are frequently, like the sponge tissue, in the condition of siliceous casts. As shown by Liebig,[1] silica when long in contact with lime in alkaline solutions becomes soluble, and hence it is that we so often find the sponges of the Chalk encased with silex, or with the interstices filled with a more or less porous mass of the same material, which is altogether adventitious to the sponge tissue. In a similar manner the mould may be refilled with carbonate of lime. On the other hand, an originally calcareous sponge may become converted into a siliceous fossil, as we see in the case of the mollusca of the Great Orme's Head and elsewhere, and that an interchange of this kind has actually taken place seems necessary to explain the fact, that siliceous and calcareous sponges are not usually found associated in the same spot.

That the calcareous sponges, those of the English Oolite for instance, are merely casts of the original structure, may be shown in another way. If then sections of the fibres be made sufficiently translucent for the employment of a quarter-inch power of the microscope, it will be seen that the fibre has often the asbestiform structure, radiating at right angles from a central axis, peculiarly a mineral arrangement, and especially of carbonate of lime. The structure of true sponge fibre on the contrary is concentric. The preservation of the sponge, therefore, in its fossil state, depends very much on the nature of the sediment in which it is embedded, and on the mode of its entombment. Hence they are met with but rarely in stiff argillaceous deposits; and although abundant in Mesozoic times, they are absent from all the clayey members of the series, such as the clays of the Lias, and the Oxford and Kimmeridge Clays; yet they occur in continental beds of corresponding ages, but differing in lithological character. At the same time it is possible that the muddy waters of the seas in which these deposits were thrown down may have been ill adapted to the well-being of the sponge, nevertheless they are met with in the Lingula Flags, and in the Upper Silurian Shales.

The condition of the sponges of the gravel pits of Farringdon is remarkable, and may perhaps tend to throw some light on the mode in which fossilization of the sponge takes place in calcareous and such sandy deposits as contain lime; and help to explain, in some manner, the absence of compression in the fossil. Every twig of the sponge presenting a free surface throughout its entire thickness, is invested by a thin coating of minute dog-tooth crystals of carbonate of lime, forming a complete crust over the fibre, much in the same manner as moss, etc., is encrusted by a calcareous spring. These crystals seldom exceed $\frac{1}{750}$ of an inch in height, the average being about $\frac{1}{1000}$ of an inch, or even less; and on their surface they are slightly tinged by peroxide of iron. All the other fossils of the same locality are similarly coated with these minute crystals, even to the interior of the cells of the Polyzoa. When slightly acted upon by dilute acids, the crystalline layer is removed, and the cast of the sponge-fibre exposed; but if the action of the acid be con-

[1] "Lectures on Chemistry," p. 491.

tinued, the whole is dissolved usually without leaving any trace of siliceous spicula.

The sand and gravel in which these fossils are embedded are loosely cemented by carbonate of lime, and it is by no means certain at what period after the sponges were entombed this coating of crystals was deposited upon them. But it is quite possible that something similar to what has taken place in these Farringdon fossils may occasionally occur in other cases as a preliminary to fossilization, in consequence of the sponge, deprived of its sarcode, having long soaked in water charged with carbonate of lime.

The ordinary mode in which fossilization takes place, however, is in one of the two following ways: either the sponge, after the destruction of its sarcode, becomes infiltrated by fine sediment which completely fills up the interstices, and forms, as it were, a mould of the sponge skeleton in which the fossilizing process takes place; or the sponge is simply buried in the deposit, which forms a nidus about it, filling perhaps the tubules and oscular passages, or even the superficial parts of the tissue, but leaving the latter for the most part open and pervious, into which mineral matter is carried in solution, and there deposited. The result of this may be, either to fill up the interspaces entirely, or merely to encrust and consolidate the fibres as in the sponges of the gravels of Farringdon; but in either case there is formed around the fibre or twig, a mould, in which the fossilizing process takes place, which is the same precisely as that which is known to take place in fossils generally, viz., the removal of the original material of the skeleton, and its replacement by another. These changes are greater and more complete in proportion to the antiquity of the deposit in which the fossil occurs.

(*To be concluded in our next number.*)

V.—On Certain Lithodomous Perforations in Derbyshire.[1]

By the Rev. T. G. Bonney, M.A., F.G.S.

In the Geological Magazine for 1870 (Vol. VII., p. 267), I published a brief account of some burrows in Derbyshire; one group of which, at the bottom of Miller's Dale, and on a scarp of rock which was probably artificial, appeared to me wholly irreconcilable with the theory which attributes them to the action of *Pholades.* This conclusion was questioned by Mr. E. Brown (Geol. Mag., Vol. VII., p. 585), who had visited the spot, and, failing to find the burrows in question, was of opinion that I had mistaken a bed of toadstone in the valley, for "limestone, and the vesicular cavities therein for the borings of animals." Fortunately, in expectation of some controversy, I had carried away a specimen, which sufficed to demonstrate (Geol. Mag., Vol. VIII., p. 40) that I really knew limestone from basalt. Wishing, however, to see whether by some inadvertence I had not quite clearly described the locality, or if the rock had been defaced after my visit, I returned thither, in the Easter vacation of the present year, with the following result:

[1] Read before the Cambridge Philosophical Society, April 29, 1872.

From Miller's Dale station, a few minutes' walk brought me down to the side of the river Wye, which is crossed by the railway on a high viaduct. A short distance down the stream we pass a mill, where a stream from Monk's Dale enters the Wye, and then come to a small inn; and a little beyond this, on the left-hand side of the road, are the burrows in question. They occur at intervals on a low scarp of rock, precisely as I described them; and, though not so large or so abundant as I have seen them elsewhere, are sufficiently characteristic to be beyond all doubt.

On referring to my previous account of the position of these burrows, I find it is perfectly correct; except that I should have called the inn "The Anglers' Rest" instead of "The Anglers," and have written "rather less than a hundred yards beyond which," for "about a hundred yards," etc. From the inn-door it is about eighty-six paces to the first group; near it is a tree (ash), growing just above the scarp, and about eight paces further on is another larger ash-tree, near to which are some more burrows. One or two bushes intervene, and burrows may be seen here and there between the above-named groups. There are some twenty in all, but I did not count them carefully. The road is from two to three yards above the stream (the Wye), as near as I can guess it; and, after a careful examination of the locality, I am now convinced that this road must have been excavated out of the hill-side, and so the scarp of limestone in its present condition is artificial. From the larger tree to the first spot where the toadstone appears is about 130 steps; but it is only exposed for a very short distance, and the principal mass is somewhat further down the dale.

I next proceeded to search the neighbourhood much more thoroughly than I had thought needful on the previous occasion. Between the aforesaid ash-tree and the inn is a small orchard, planted on the sloping bank between the above-named road, and another which branches off near at hand, and goes, I believe, over the hills to Tideswell. This grassy slope is broken by a small reef of limestone, the upper slab of which projects a foot or so, and is polished by the friction of sheep's backs.[1] It is about four yards nearer the inn than the smaller tree, and five yards up the bank. The under side of this projecting slab is pierced by many burrows; some of which are full two inches deep and three-quarters of an inch wide. Again, between the larger tree and the first boss of toadstone, about thirty-eight paces from the former, and on the sloping bank—some five feet below the wall of the upper (Tideswell) road, and twenty-five above the lower (exactly above a ruined sheep-pen by the side of the Wye)—is a projecting block of limestone, about two feet high, with nearly twenty burrows; three of these contained very old dead shells of *Helix nemoralis* cemented into them.

Again, a few yards beyond the first appearance of the toadstone, and about forty feet up the bank, several bolder cliffs break out; on one of the nearest of which an ash-tree is growing. Here, also, burrows are abundant.

[1] See a similar case described by Mr. Rofe, Geol. Mag., Vol. VII., p. 5.

After this I searched no more in Miller's Dale, but went on by the Wye, until I came to the entrance of Tideswell Dale, up which I turned. After walking about a third of a mile (some 300 yards from the sharp turn where we lose sight of the entrance to the dale), a bed of limestone rose from the roadside on the right bank, and mounted gradually up the sloping side of the valley. Here, attracted by the appearance of the rocks, I again began to search, and found the burrows at intervals, commencing a few feet above the road. Some 40 feet above the stream rose a small crag, about four feet high, in the upper part of which they were very abundant; from this I detached a fine specimen, which I have placed in the Woodwardian Museum.

I then walked on to the marble quarry mentioned by Mr. Brown (Geol. Mag. Vol. VII., p. 585). Here I found burrows plentifully, in reefs of limestone projecting from the hill-side right and left of the quarry, and nearly on the horizon of the marble-bed. Again, I noticed them on a crag just off the road on the left bank of the valley, and two or three hundred yards out of Tideswell. Returning thence I followed, for a short distance, the upper road on the right bank of the valley; and here, shortly before coming opposite to the quarry, I saw that some projecting slabs at the top of a crag by the roadside were riddled by burrows. Though, owing to the steepness of the scarped rock, I could not actually reach these, I could see them distinctly. I have no doubt that had I continued the search, I could have found many more. Seeing, then, that I find my description of the locality was substantially correct, and that these burrows are so very abundant, both in Miller's Dale and Tideswell Dale, I am unable to understand how it was that Mr. Brown failed to find them.

In conclusion, I will add a few remarks on the general question of the nature of these burrows. Some have supposed that these holes are the result of weathering, either by fossils dropping out of the matrix, or by the solvent action of carbonated water drilling the rock—a process in some respects analogous to the formation of a sand-pipe. Now, as to the former of these theories, I can only remark, that in all the cases where I have found the burrows, fossils are conspicuous by their absence; as to the latter, though it is true that we often see forms not unlike them, and though in some of the rocks in which they occur irregular semi-tubular hollows are common,—though, in a word, we occasionally get natural forms with some resemblance to the burrows,—yet I think no one who has seen them in large numbers can fail to be convinced that they cannot be accounted for by any purely chemical theory. I believe, however, that the burrower has sometimes availed itself of a previously existing depression. I may observe that so far as my observations at present go, these burrows are usually found in a very pure homogeneous limestone, with a marly fracture and rather chalky surface, but which is nevertheless very hard. So marked is this that I can often tell from the appearance of a rock whether I shall or shall not find burrows in it.[1]

[1] For example, during a brief visit to Cheddar last July, I did not come upon

Of those who assign to the burrows an organic origin, some attribute them to the work of *Pholades*, others of *Helices*. I have endeavoured in these communications[1] to shew that the form, direction, and position of the burrows, not only do not correspond with those of *Pholades*, but also are such that it is impossible that these molluscs could have excavated them; and, further, that the presence of these burrows almost at the bottom of such well-marked valleys of river erosion as Miller's Dale and Tideswell Dale, is quite irreconcilable with any 'marine' theory. They must, therefore, be the work of some terrestrial animal. I have found snail-shells abundant in their immediate neighbourhood, dead shells in evidently disused burrows, and living snails in those which presented the freshest and most unweathered surfaces.

It seems, therefore, only a fair inference to consider these the work of *Helices*, and as such they have an interest rather for the zoologist than the geologist.

On former occasions I have been led to connect *Helix adspersa* chiefly with the burrows; but on this I noticed that the burrows as a rule were of rather less diameter than the majority of those at Llandudno and on the hill behind Matlock, and that *Helix nemoralis*[2] (and sometimes *H. lapicida*[3]) was the usual occupant.

Now that attention has been drawn to them, they will probably be found abundantly, and it may be possible to discover by further observation the precise mode of excavation, whether by mere friction, by an acid secretion, or by both agencies;[4] as well as the purpose for which they are made. If it be for hybernation, it is strange that the animals should take this trouble, when there are often cracks and recesses near, with which, had the rock not been limestone, they would have remained content.

VI.—Notes on some Valleys of Erosion.

By H. Alleyne Nicholson, M.D., D. Sc., F.R.S.E.,

Professor of Natural History and Botany in University College, Toronto.[5]

During the summer of last year I had the opportunity of visiting various localities in the State of New York which are of great geological interest; and I was particularly struck by the numbers of valleys which are exclusively the work of the rivers by

quite the right kind of rock, and only found two or three burrows—and these in a boulder—that satisfied me. It will not, however, surprise me if they are found there; for I had other matters in hand, and was too hurried to look carefully for them. Mr. Main, Lecturer in Chemistry at St. John's College, Cambridge, has kindly analyzed for me a fragment of the limestone from Derbyshire. He finds only 3·5 per cent of foreign matter, the rest, 96·5, being carbonate of lime.

[1] Geol. Mag. Vol. VI., p. 483; VII., pp. 93, 267.

[2] The same species is described as tenanting burrows, especially in winter, by Mr. Hodgson, *Jameson's Edin. Journal*, 1846, p. 396.

[3] Linnæus gave this name, I find, from a belief that it bored limestones. Mr. N. Goodman informs me that the burrows at Monte Pellegrino are made by a fourth species of Helix.

[4] See for a fuller discussion of this a paper by Mr. Rofe, Geol. Mag. Vol. VII., p. 4.

[5] Read before the Royal Physical Society, Edinburgh, April 24th, 1872.

which they are occupied, as compared with those which are in every way caused by mechanical disturbance of the beds through which they run. The great Silurian series of the State of New York presents an appearance which at first sight seems most anomalous to one who has been accustomed to the Silurian districts of the North of England, the South of Scotland, or Wales. In place of having the beds dipping at high angles, contorted and folded in every manner, repeated or abbreviated by faults, the Silurians of New York are found succeeding one another with the utmost regularity, for the most part in a nearly horizontal position, and rarely either flexured or interfered with by dislocations of any magnitude. One result of this state of things is that the rivers, in making their way from the high grounds to the sea, have mostly cut for themselves more or less profound ravines, which are generally pure instances of aqueous erosion; and which are very similar, on a small scale, to the "cañons" of Colorado and Nevada. One of the most striking instances of these valleys of erosion is to be found in what is known as "Watkins Glen," in Western New York, a now famous resort for lovers of the picturesque. Watkins Glen derives its name from the town of Watkins, which is situated at the head of Seneca Lake in Schuyler County. The lake—which is about forty miles in length—runs due north and south, and the stream which forms Watkins Glen runs nearly due east and west. The lake itself is a long shallow depression scooped out of strata of Devonian age, which strike nearly east and west, and are nearly horizontal, or have a slight and almost imperceptible dip to the south. It follows from this that Seneca Lake runs at right angles to the strike of the beds amongst which it is placed. On the other hand, the lateral streams which flow into Seneca Lake from the east and west run more or less accurately along the strike of the strata through which they cut their way. Watkins Glen is a magnificent example of a ravine which has been entirely formed by the stream which now occupies it, and it is only one of many smaller ravines which intersect the eastern and western shores of Seneca Lake. The stream in summer is very diminutive, but its dimensions are doubtless very considerable when swollen by the melting of the snows in spring. The ravine is about one mile in length, and in this short space the stream falls no less than four hundred feet, its course being an uninterrupted succession of small cascades with intervening rapids. Small as the actual stream is, the dimensions of the ravine are very striking. For a distance of about a mile the stream runs between nearly vertical walls of rock, which vary from one to two hundred feet in height. The breadth of the ravine rarely exceeds forty or fifty feet, and the sides are for the most part nearly parallel from the bottom to the top, showing that the action of the stream has been nearly uniform for a long period. The rocks through which the stream cuts belong to the Portage Group (Upper Devonian), and consist of dark shales and flagstones, which are nearly horizontal or have a slight inclination to the south. That the valley is one of pure erosion admits of no doubt, for the beds can be seen crossing unbroken from one side to the other, whilst the bed of the stream is often the uninterrupted surface of a single stratum. There is, therefore, no reason to call in the aid of any mechanical disturbance to account for the phenomena of Watkins Glen. There is, however, a marked physical peculiarity in the strata of the Glen upon which many of its features can be shown to depend. The beds, namely, whilst nearly horizontal, are intersected in the most regular manner by two sets of vertical joints, the one set striking N. and S., whilst the others run E. and W. These two sets of joints are, therefore, perpendicular to one another, and they divide the entire mass of strata into a series of oblong blocks. The N. and S. joints are placed at intervals of about three feet from one another; the E. and W. joints at a distance of five or six feet, and the faces of both are approximately vertical. Other irregular joints are not absent, but these may be left out of account. As I have before remarked, the stream runs nearly due east and west, so that its course corresponds with the one set of joints, and is perpendicular to the other. The effect of these joints on the work of erosion is readily seen. All the cascades over which the stream is precipitated are formed by the faces of the north and south series of joints, the stream gradually cutting back from the face of one joint to that of the next. On the other hand, the bed of the torrent between the cascades has been scooped out along the east and west series of joints. The rock itself is so uniform in character, and so devoid of alternations of harder and softer beds, that there can be no hesitation in regarding the above as the true explanation of the formation of this wonderful ravine.

Very different causes have been at work in the formation of the well-known gorge of the Genesee at Rochester, and the still more celebrated ravine through which the Niagara River cuts its way below the Great Falls. In both these instances we have examples of gorges which owe their origin to the action of running water upon beds of unequal hardness. At Rochester, the Genesee River has made for itself a long and precipitous ravine, which is terminated at the city of Rochester itself by the beautiful Falls of the Genesee. The strata through which the river cuts have a slight southerly dip, and the stream itself flows nearly due north, so that its direction is at right angles to the inclination of the beds. As seen immediately below the Falls, the sides of the gorge are seen to be composed of a very hard, compact, bluish or grey limestone (the Niagara Limestone), capped by a mass of genuine glacial drift. On reaching the bottom of the ravine, however, the Niagara Limestone is seen to be underlaid by bluish-grey fissile shales (the Niagara Shales), replete with Wenlock fossils. The bed of the stream below the Falls is excavated in these comparatively soft shales; and it is over the much more resisting limestone that the river is precipitated to form the cataract. The action of the stream under these circumstances is extremely obvious, and has been repeatedly pointed out in the case of the Great Falls of Niagara. The stream, namely, gradually cuts its way back, by constantly wearing away the soft shales below the Fall, and thus leaving the hard limestone which forms the lip of the cataract without support. In this way great masses of tho limestone are constantly breaking off along lines of jointing, and the Falls are gradually receding up the river, and the length of the ravine below the cataracts is constantly being increased. If the strata through which the river cuts were quite horizontal, there would be no limit to the recession of the Falls and to the length of the gorge which might be formed in this way. But, the strata have a slight dip in the opposite direction to that in which the river flows, or in the same direction as that in which the Falls are receding. It results from this that when the river has cut its way back for a certain distance, the conditions of the case must change. The hard and compact limestone which now forms the edge of the Falls will ultimately come to form the bed of the river; and as the strata which succeed this upwards are of a softer nature, the place of a single fall with a long ravine below it will finally be taken by a continuous rapid or a succession of minor cascades. As has been pointed out by Hall and Lyell, this is precisely the action which is going on at the Falls of Niagara, but upon a gigantic scale. I have endeavoured to show, however, that very similar phenomena may be produced under very different conditions; as is seen in Watkins Glen, where the strata through which the stream cuts are of a very uniform nature, but are regularly intersected by two sets of vertical joints cutting one another at right angles.

VII.—Grooved Boulders in Diluvial Clay, Watson's Hospital, Edinburgh.

By W. T. Black, Esq.

The excavations for the foundations of the new Infirmary in the grounds of Watson's Hospital, Edinburgh, have disclosed several Boulders, which appear lying in the Diluvial-clay. This is a marly clay, and has been dug to the depth of about five feet, in several horizontal terraces, down the slope from north to south. These Boulders were of sufficient size to be left behind *in situ* by the labourers, and about six large ones were found in the north and twelve in the south area of the grounds. They were of trappean rock chiefly, being rounded on the angles and sides, and of a dark green crystalline structure internally, A large one in the north area was of a metamorphic granitic character; one in the same area of a buff-coloured sandstone; and another in the south was composed of the same rock, and grooved also.

The grounds are in the form of an unequal quadrilateral figure, of the mean length of 850 feet and breadth of 750 feet, and are divided into two areas north and south by the buildings of the hospital.

The slope of the grounds of Watson's Hospital is towards the south, down to the Meadows, from Lauriston Street, on the north; and the angle may be about $2\frac{3}{4}°$, or 1 foot in 20. In the northern area, the dimensions of the larger granitoid Boulder (No. 2) were 1ft. 8in. high, 2ft. 4in. long, and its horizontal circumference was 7ft. 6in., and the depth of the platform it was found on was 4ft. 8in.

The dimensions of the smaller trap Boulder (No. 1), in the north area, were 1ft. high, 1ft. 9in. long, the horizontal circumference was 5ft. 5in., and the depth of the platform 5ft. from the surface.

Both of these Boulders were grooved all over their upper surface, and the markings were all in one direction, except one or two streaks might be somewhat diagonally placed with respect to the others. The depth of the grooves was about $\frac{1}{8}$ to $\frac{1}{4}$ of an inch, and the breadth $\frac{1}{4}$ to $\frac{1}{2}$ an inch or more, and they extended right across the planes they scored, some being as long as 12 inches, and some as short as 2 inches.

Many of the grooves started abruptly into the surface of the boulder, whence they gradually shaded off to streaks, which some of them began with and ended, while the middle was deeply cut.

The Boulder (No. 3), without grooves, lying in the eastern cutting on the north area, was of the usual trappean description, with rounded edges and corners, and laminæ on the surface, that peeled off in superficial cakes.

Its dimensions were: 1ft. 4in. deep, 1ft. 9in. broad at the larger end, 2ft. 9in. long, with a horizontal circumference of 7ft. 5in., and it lay loose on the platform.

A flat Boulder (No. 4), of buff-coloured sandstone, in the north area, lay loose on the surface, and had its upper surface scored with deep grooves more or less parallel.

In the southern area of the hospital grounds were found, exposed in the excavations, about a dozen other Boulders, all of trappean character except No. 7, which was of a violet-coloured crystalline sandstone. Of these, eight were found scored with grooves of a similar character as those described on the boulders in the north area, and the sandstone block, No. 7, was also well marked with streaks.

The dimensions of one in the west cutting (No. 10) were: 1ft. high, 1ft. 7in. long, 1ft. 5in. broad, and it was 5ft. 6in. in circumference, oval in shape, and had grooves on two sides, all in the same direction, and the depth of the platform was about 2ft.

In the middle cutting was a large rounded one (No. 11), *in situ*, in the bank and near the surface of the soil, when the upper surface had only grooves, and these, like the last, tended all down hill.

Its dimensions were: length, 2ft. 3in.; height, 1ft. 4in.; and depth of platform, 2ft.; so that the soil above it was 8 in. deep, and of this half was of loam and the rest the marly subsoil.

None of the above-mentioned Boulders were seen to lie on the subjacent rock, but were all lying in the middle or near the top of the clayey stratum.

The rocky bed below this has only been exposed in one place in the south area, at about six feet below the surface, and this is a buff-coloured soft sandstone superficially, but of more densely crystalline structure deeper.

These igneous Boulders can be conjectured to have been carried by glacial or aqueous agency from numerous sources in the neighbourhood of Edinburgh; as the Castle Hill to the north, Corstorphine

Hill to the west, and Arthur's Seat to the east, which are greenstone eminences not far distant.

As to the agent producing the grooves, the general impression from their up and down hill course seemed to be that they were caused by the ploughshare in times gone by, when the locality might have been under cultivation for grass.

The probabilities against these grooves being due to glacial action rest chiefly upon their not being smoothened or polished, and their course curving over the rotundity of the upper surface of the boulders, and the starting of some channels by sudden indents in the stones. It may, however, be stated that the overlookers on the works think that some of the boulders lie too deep to have been marked by the old kinds of plough, and that these lie also in undisturbed subsoil, below the loam on the surface.[1]

The evidence on this subject indicates that No. 1 grooved Boulder and No. 2 were both about three feet below the surface, No. 10 was one foot, and No. 11 was eight inches; while, again, Nos. 7 and 8 grooved Boulders just appeared on the level of the original slope of the ground.

The Secretary of the Institution has informed me that the grounds have not been used for agricultural purposes since the building of the Hospital in 1738. Previous to that event it was common land, called Heriot's Croft, and was probably meadow land when purchased by Watson's Trustees from those of Heriot's Hospital.

NOTICES OF MEMOIRS.

I.—Memoirs of the Geological Survey.

We have much pleasure in stating that Part I. of the Memoir by Mr. W. Whitaker, B.A., F.G.S., on the Geology of the London Basin, has just been published. It occupies over 600 pages, and includes an account of the Chalk and the Eocene beds of the Southern and Western Tracts, lying in the counties of Berks, Bucks, Essex, Herts, Kent, Middlesex, Surrey, etc., with parts, by H. W. Bristow, F.R.S., Director, T. McK. Hughes, M.A., F.G.S., and notes from other members of the Geological Survey of England. We hope, in a future number, to give a more extensive notice of Mr. Whitaker's work, which, from the amount of detailed information on the Geology, together with the appendices on the Bibliography, Well Sections, and Fossils, cannot fail to be of great practical as well as scientific value.

[1] An eminent Scottish Geologist writes to the Editor that "the *true* glacial striæ in the neighbourhood of Edinburgh all go from west to east; whereas the direction of the striæ on the erratics, examined by Mr. Black, appear to go from north to south." This, he thinks, "looks like *the plough*." "Striated pavements of Boulders," he adds, "are *great rarities;* Hugh Miller has recorded a single instance." —Lyell's Elementary Geology, p. 147. Chambers' Papers, Proceed. Royal Soc. of Edinburgh, April 20th, 1857.

II.—Colliery Explosions and Weather. Being an abstract of a paper read before the Royal Society on the 18th May, drawn up by Robt. H. Scott, F.R.S., Director of the Meteorological Office, and W. Galloway, Esq.

After a preliminary reference to previous papers on the subject, and especially to the diagrams published by Mr. Joseph Dickinson and by Mr. Bunning, of Newcastle-on-Tyne, the authors of the paper referred specially to Mr. Dobson's paper, published in the reports of the British Association. They showed that the periodicity alleged by him to exist in these explosions had no real foundation in fact, for on plotting the dates of the explosions for the last 20 years in two 10-year periods very slight resemblance was seen between the two curves. The number of accidents, all fatal ones, on which this statement was based, was 1369.

In the progress of this inquiry it had come out that the number of serious accidents, involving the loss of 10 lives or more, had materially increased during the last 5 years, the numbers being—

1851–5 XIII.	1856–60 XV.
1861–5 XII.	1866–70 XXI.

These numbers appear to be well worthy of remark.

For the special purpose of the paper the continuous records from Stonyhurst, one of the observatories in connexion with the Meteorological Office, were taken, and the curves for the barometer and themometer were plotted for the 3 years 1868-70. The records of fatal explosions were obtained from the published reports of the inspectors, while the dates of the non-fatal accidents were obtained from the inspectors themselves, who, almost without exception, replied to the communications addressed to them, and furnished the desired information. Mr. Dobson, in his paper, having spoken of the explosions occurring principally at the commencement of a storm, the authors showed that it was not in some cases until two or three days after the barometer had reached its lowest point that the accident happened. They showed also why, during a period of continued violent oscillation of the barometer, the passage of each successive barometrical minimum is not characterized by an equal number of explosions, the largest groups of accidents being reported where a serious break occurred after a period of calm weather. The effect of a high temperature of the air in interfering with ventilation, and especially with natural ventilation, was also explained, and it was shown how the first hot days in spring were marked by explosions.

The actual dates of the explosions for the three years in question were then compared with the meteorological records, and it was shown that out of 550 explosions—

266 or 48 per cent. might be attributed to the state of the barometer;
123 or 22 per cent. to the state of the thermometer;
161 or 30 per cent. remained unaccounted for on meteorological grounds.

The next point touched upon in the paper was the action of a more or less impure ventilating current in increasing the explosive character of the air in all parts of the pit, and possibly in causing an explosion in a place which would have remained safe had the ventilating current itself remained pure. It was shown how, when an explosive mixture had been formed in places, and under conditions similar to those described, some time—possibly several days—must elapse before the contents of such an accumulation of dangerous gases shall have been rendered innocuous again.

The effect of warm weather in stopping natural ventilation was explained, the natural temperature of a mine of a depth of 50 fathoms being 55 degrees, that of one of the depth of 200 fathoms 70 degrees, and so on. Speaking generally, it was shown that if the temperature of the air rose to 55 degrees, natural ventilation must cease in shallow pits; and similarly in other cases. Accordingly, if a warm day occurs in the cold season of the year, and the furnaces are not in action, an explosion is very likely to occur.

These statements were illustrated by one instance of a fatal explosion, the cause of which had been declared by the inspector to be inexplicable, the pit having strong natural ventilation. It appeared, however, that the explosion occurred on a warm day, while the inspector visited it twice on colder days after the explosion, so that the state of ventilation which he witnessed had no reference to that which must have prevailed when the accident happened.

The paper concluded by stating that it appeared that the evidence fairly justified the view that meteorological changes were the proximate causes of most of the accidents, it being remembered, as has before been observed, that the records contain no account of the number of times when the pits have been too dangerous for the men to go down, and so explosions have not happened. Whatever be the meteorological changes, it is absolutely necessary to keep a most careful watch over the amount of air passing through the workings.

Thirty years ago, George Stephenson said, in a letter to the South Shields Committee, referring to explosions—"Generally speaking, there has been some fault in the ventilation of the mines when accidents have happened," and the same opinion is held by many of the most experienced authorities at the present day. In this matter the one cry, whether we look to security against explosion, or to the affording to miners an atmosphere which they can breathe without injury to health, is—"More air."

REVIEWS.

I.—Palæontographical Society. Vol. XXV. Issued for 1871. June, 1872.[1]

AGAIN it is our pleasant task to record the issue of another annual volume of the publications of this most useful Society, which devotes its funds to the illustration of British fossils of all ages, and has already issued many monographs and hundreds of plates of Mammals, Reptiles, Molluscs, Crustacea, Echinodermata, Radiata, Fossil plants, etc., etc.

[1] The notice of vol. xxiv., issued for 1870, will be found in the Geol. Mag., Vol. VIII., 1871, p. 175.

The volume before us contains the following parts:—

1. The Flora of the Carboniferous Strata. Part III. By E. W. Binney, F.R.S., F.G.S. pp. 63–96. pl. xiii.–xviii.
2. The Fossil Merostomata. Part III. By Henry Woodward, F.G.S., etc. pp. 71–120. pl. xvi.–xx.
3. Supplement to the Crag Mollusca. Part I. By Searles V. Wood, F.G.S. pp. 1–90. pl. i.–vii. Together with an Introductory Outline of the Geology of the same District, with a Map, by S. V. Wood, jun., F.G.S., and F. W. Harmer, F.G.S. pp. i.–xxxi.
4. Supplement to the Reptilia of the Wealden. (No. IV.) By Prof. Owen, F.R.S. pp. 1–15. pl. i.–iii.
5. The Pleistocene Mammalia. Part IV. By W. Boyd Dawkins, M.A., F.R.S., etc., and W. Ayshford Sanford, F.G.S. pp. 177–194. pl. xxiv. and xxv.
6. The Pleistocene Mammalia. Part V. By W. Boyd Dawkins, M.A., F.G.S., etc. pp. 1–30. pl. i.–v.

1. In Mr. Binney's contribution will be found, besides introductory remarks, the bibliographical history and general observations upon *Lepidodendron* and *Halonia*, together with descriptions and figures of specimens referred to *Lepidodendron Harcourtii*, *Sigillaria vascularis*, and *Halonia regularis*. None of these species are new to science; but the plates, prepared, for the most part, from exquisite sections, showing the microscopic structure, are drawn with extreme skill by Mr. J. N. Fitch, of the Royal Botanic Gardens, Kew, and well maintain the admirable character of the author's monograph.

2. Mr. Woodward contributes another portion of the History of the Merostomata, which is to be completed in the 4th part, now in the press. It includes *Pterygotus raniceps* from Lanarkshire, seven species from the neighbourhood of Ludlow, Kington, etc., given on the authority of Mr. J. W. Salter, and a full account of *Slimonia acuminata,* one of the most perfect forms yet discovered in the Upper Silurian of Lesmahagow. A nearly entire example of this species, measuring 26½ inches, figured of the natural size, forms the subject of one of the plates (pl. xvii.). An outline restoration of *Slimonia* is also given on pl. xx.

3. Mr. Wood's supplement to the Crag Mollusca,[1] which treats only of the Gasteropoda and one Pteropod, is preceded by an interesting notice of 28 pages, by his son and Mr. Harmer, on the Geology of the Upper Tertiaries of East Anglia, accompanied by a map and sections, the result of their labours in the Eastern Counties for several years past, and including the Coralline and Red Crags, the Chillesford Beds, the Forest Beds, the 'Lower,' 'Middle,' and 'Great' Chalky Clay, or 'Upper' Glacial series, together with remarks upon the so-called Plateau-gravel and Post-Glacial formations.

In a monograph on Crag Mollusca, the addition of a sketch of the geological relations of the several formations enhances greatly the value of the work as showing the true geological sequence of the

[1] Mr. Wood's Original Monograph on the Crag Mollusca appeared in 1847, and formed the first publication of this Society.

strata from which the fossils were obtained. Mr. Wood describes above twenty Mollusca from the Crag, which are either new additions to the fauna or rectifications of others already named.

4. Professor Owen's Monograph is devoted to a description of the bones of the fore-arm and paw of the *Iguanodon,* and is important as showing that what was considered by Dr. Mantell to have been the "horn" is now known to be a spur attached to the distal end of the radial bones, and which in a former Monograph Professor Owen inferred, from its unsymmetrical character, to be one of a pair of bones conjectured by him to be "phalangeal." The author also illustrates the bones of the fore-foot not previously described, and which "give evidence that the fore-paw was pentadactyle, and that the terminal phalanges, at least some of the toes, were short, obtuse, rough, serving for the support of horny matter in the shape of a hoof rather than that of a claw."

5. Messrs. Boyd, Dawkins, and Sanford contribute a fourth part of the British Pleistocene *Felidæ,* including the character, range, and associated animals of *Felis pardus, F. caffer, F. catus,* and *Machærodus latidens.* Of the six species of *Felidæ* noticed in this and the preceding Monograph, two have been added by these authors to the catalogue of British fossil animals,—the panther, or leopard, and the *Felis caffer,*—the latter of these having been hitherto unknown in Europe. This animal, as well as the lynx, panther, wild-cat, *Felis spelæa,* or lion, lived during the Pleistocene age.

Machærodus latidens is the only aberrant member of the Felidæ in Pleistocene times which has become extinct. To account for the absence of the Lion in prehistoric times in Europe (whereas it occurs both in the Pleistocene and Historic periods), Mr. Dawkins suggests that during the long interval which elapsed between these latter, it had retreated from Northern and Central Europe partly from the competition with man, and partly from the operation of the same obscure causes which banished the Spotted Hyæna and the Hippopotamus to Africa.

6. Mr. Dawkins gives, in Part V., a fair history of the *Ovibos moschatus*—both as to its distribution in Great Britain and the Continent, and adopts De Blainville's views in placing it among the Ovidæ instead of the Bovidæ as heretofore.

In this country it has been found at Crayford, Green-street Green, Freshford near Bath, Barnwood near Gloucester, and at Salisbury.

It has also been found in France, Germany, Siberia, and America, on the Northern Continent of which it is now found living, ranging over the "Barren Grounds" and the River Mackenzie through 105 degrees of latitude. The Musk-sheep proves to have had a greater range in time than was formerly suspected, having been a contemporary of the Megarhine Rhinoceros during the Pleistocene period when the Lower Brick-earths of the Valley of the Thames were being deposited.

We heartily congratulate Mr. Wiltshire on the excellent working of this Society, which owes a large proportion of its success to his energetic and practical action as its Honorary Secretary.

II.—The Bendigo Gold-field Registry: comprising Introduction for the Year, Comparison of Yields, Digest of Dividends, Table of Depths, Progress and Present Position of the Chief Reefs, and Lists of Companies, Terms, etc. By J. Neill Macartney. With Plans, by H. B. Nicholas, C.E. Also Notes on the Bendigo Gold-field (Illustrated), by W. Nicholas; and a description of Fryer's Creek Claims, with Plan. Second year. Melbourne, 1872. 8vo., pp. 120. London: Trübner and Co.

THE discovery of Diamond-fields at the Cape and the rush in that direction, together with the development of Iron-mining at home to an almost unparalleled extent, has, for a time at least, diverted a large share of public attention from the Australian gold-fields, which nevertheless are still being carried on with great energy and no little success.

The Bendigo gold-field is a good illustration in point.

"The yields of 1871 are in excess of 1870, and the spirit of speculation, which was considered to have been well nigh exhausted in the formation of 300 companies, is more vigorous than ever. During the past ten months of 1871, 765 companies have been registered in over eighteen million shares."

Up to November, 1871, the total number of registered companies was 1310; an estimate of a few selected mining claims in Garden Gully Stock shows a value of over £2,000,000; whilst the whole of the Bendigo mines are valued by the author at £10,000,000.

An abundant supply of water appears to be greatly desiderated, but the want is likely to be met by a Bill now before the Legislature by which the Waterworks Company will dispose of their works to the City Council, who are prepared to bring in a good supply from the Coliban.

The article on Quartz Reefs contains some excellent advice to miners, but it is chiefly based on the admirable work by Mr. R. Brough Smyth (see Review in Geol. Mag., 1869, Vol. VI., p. 459), entitled "The Gold-fields of Victoria."

Mr. R. B. Smyth was mainly instrumental, by his evidence laid before the Colonial Legislature, in checking the idea that quartz-reefs diminished in richness as their depth increases. Mr. Smyth submitted tables and statistics, proving that there was no diminution of gold in the reefs of this colony from the surface to 400 feet in depth; and in his later work, above quoted, he affirms that there is no diminution in the richness of quartz-reefs at 700, 800, or 900 feet beneath the surface. Many of the examples of this successful deep-mining are to be found in Bendigo.

The book is principally occupied with maps and plans of the claims, etc., which it is beyond our province to notice here.

The principal interest arises from the evidence it affords of what may be done by skill and practical experience when aided by capital. Without the vast amount expended on machinery, these intractable reefs of quartz would never have yielded up to the miner their safely-bound and often widely-diffused auriferous treasure.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—May 8, 1872.—Joseph Prestwich, Esq., F.R.S., in the Chair.—The following communications were read:—1. "Notes on Atolls or Lagoon-islands." By S. J. Whitnell, Esq. Communicated by Prof. Maskelyne, F.R.S., F.G.S.

The author commenced by indicating certain facts which lead him to think that the areas of atolls are not at present sinking, and referred to one instance (that of Funafuti or Ellice Island) in which he thought there were signs of a slight upward movement. He noticed the occurrence of a furrowed appearance, or a series of ridges or mounds, in some islands, each of which he regarded as produced by a single gale. He also described a freshwater lagoon, about three miles in diameter, as occurring in the island of Quiros.

Discussion.—Mr. Thorpe was acquainted with the atolls around the coast of Ceylon, and thought that the local traditions, untrustworthy as such sources usually were, might afford some evidence as to the date of their origin. The tradition in Ceylon was that the Maldive and Laccadive Islands had within the memory of man been connected with Ceylon. If this were so, the evidence was in favour of the area being one of subsidence.

Mr. D. Forbes, when in 1859 he spent some months in the Pacific, had been requested by Mr. Darwin to examine into the evidence as to the origin of these atolls by elevation, and had found that the asserted cases of the existence of masses of coral at a considerable elevation above the sea merely arose from blocks having been transported inland by the natives. Though, however, there was no evidence of elevation, it was still possible that such had in certain cases taken place, as there were still active volcanoes in this region. The freshwater lakes he attributed to the drainage of the islands.

2. "On the Glacial Phenomena of the Yorkshire Uplands." By J. R. Dakyns, Esq. Communicated by Professor Ramsay, F.R.S., V.P.G.S.

The author stated that in Derbyshire and Yorkshire, south of the Aire, there is no glacial drift on the eastern slope of the Pennine chain, except where it is broken through by the valleys of the Wye and of the Aire and Calder. The basin of the Aire and the country northward are thickly covered with drift, which contains no rocks foreign to the basin, and thus points to formation by local action. The author ascribed this to the glaciation of the country in part by glaciers, and in part by a general ice-sheet. Evidence of the latter he finds in the fact that drift occurs only on one side of the valleys, namely, on the lee-side of the hills with respect to the source of the drift materials. Traces of the action of glaciers are, the great amount of scratched and rounded pebbles in the mounds of drift, which increases in proportion to the distance from their source; the presence of great piles of drift at the junctions of valleys, as if by the shedding of the lateral moraines of two glaciers; and the existence of mounds of pebbles and of an alluvial deposit wherever a rock-basin crosses a valley. The Kames or Eskers, which are frequent in the valleys, he ascribed to the deposition of moraines in the sea instead of on land.

Discussion.—Prof. Ramsay agreed with the author as to the existence of these rock-basins in the Yorkshire area, and as to the absence of marine drift on great part of the slope of the Pennine chain. The terminal moraines had to some extent become obscured by the washing in of soil by rain; but their ancient existence in many of the Yorkshire valleys was indisputable. The features of the country were, moreover, in many instances such as could not be reconciled with the deposition of the drift by marine action.

3. "On a Sea-coast Section of Boulder-clay in Cheshire." By D. Mackintosh, Esq., F.G.S.

The principal object of the author was to draw attention to the fact of the occurrence of numerous sea-shells in a lower boulder-clay at Dawpool, as thoroughly *glacial* in its appearance, structure, and composition, as any clay to be met with along the shores of the Irish Sea, and differing in no essential respect from the *Pinel*, which runs up the slopes and valleys of the Lake District. He pointed out a number of very important distinctions between the Lower and Upper Boulder-clays of Cheshire, referring especially to the light grey or blue facings of the fractures of the latter. He gave a list of a number of large boulders, greenstone and Criffell granite predominating, though among the smaller stones Silurian grit was most prevalent. The author likewise explained the mode of striation of the stones found in the clay, and the positions they occupied in reference to their flattened surfaces.

The paper was illustrated by samples of the two clays, a number of shells in various states of preservation, and about forty specimens (most of them named and their parentage assigned) of Silurian grit and argillite, greenstone, several varieties of felstone and porphyry, felspathic breccia, Criffell and Eskdale granites, and granites of unknown parentage, Wastdale or Ennesdale syenite, quartz, Carboniferous-limestone, chalk-flints (?), local gypsum, sandstone, etc.

In a letter Mr. Searles V. Wood, Jun., stated that he regarded the Boulder-clay containing the shells as later than the newest of the East-Anglian beds, and the Upper clay as probably equivalent to the Hessle clay.

The fragmentary shells sent had been determined by Mr. J. Gwyn Jeffreys, who found eleven species represented among them, and stated that they agreed with the shells from Moel-Tryfaen and Macclesfield. He remarked especially on the occurrence of *Astarte borealis*, a species now extinct in the British area.

Discussion.—Prof. Ramsay remarked, with regard to the Bridlington beds which had been cited, that they were probably preglacial, and not glacial. He thought that eventually it would be proved that during the Glacial Period there had been several oscillations in this country both in level and in temperature. With respect to temperature, the calculations of Mr. Croll showed the extreme probability of such variations being due to astronomical causes; and these were best illustrated by reproducing his figures in the form of a diagram, showing the curves and oscillations of temperature.

4. "On Modern Glacial Action in Canada." (Second Article.) By the Rev. William Bleasdell, M.A. Communicated by Prof. J. W. Dawson, LL.D., F.R.S., F.G.S.

In this paper the author communicated some facts illustrative of the action of ice in Canada, in continuation of a former paper. Fidlar's Island, in the rapids of the river Trent (flowing into the head of Lake Ontario), has been removed within the last eighteen months. Patrick's Island, a mile lower down, is also rapidly disappearing. Salmon Island, in Bay of Quinte, between Amherst Island and the mainland, which had an area of about an acre fifty years ago, has disappeared, leaving a shoal, with about 4 feet of water over it; and three neighbouring islets, known as the Brothers, are in course of removal. The removal of these islands is due to the action of drift-ice. The author also referred to the formation of ground-ice in the Canadian rivers.

Discussion.—Prof. Ramsay mentioned that Sir William Logan had informed him that shore-ice in Canada, charged with boulders, had been known to produce grooves on the face of cliffs as well marked as those of glacial times. He had also mentioned the case of a boulder transported by ice which was of such a size as to have occasioned the wreck of a vessel which had struck upon it.

II.—May 22, 1872.—Prof. Morris, V.P., in the Chair.—The following communications were read:—1. A communication from the Rt. Hon. Earl Granville, inclosing a report from H. M. Minister at Rome relating to the recent Eruption of Vesuvius.

2. "On the Phosphatic Nodules of the Cretaceous Rock of Cambridgeshire." By the Rev. O. Fisher, M.A., F.G.S.

This paper contained an attempt to explain the origin of the phosphatic nodules which lie in a thin bed at the base of the Chalk in Cambridgeshire, and are largely extracted by washing the stratum for the purpose of making superphosphate of lime. Two hundred and seventy tons per acre, at the rate of fifty shillings a ton, represents the valuable yield of the deposit, which is followed to the depth of about 18 feet. The nodules and other fossils of the bed are chiefly derivative, forming a concentrated accumulation from a deposit belonging to the Lower Cretaceous period. Some of the fossils are, however, believed to be indigenous to the deposit. *Plicatulæ* are attached to all the derivative fossils and nodules, and the sharp broken surfaces of the latter, with *Plicatulæ* on them, show that they were mineralized before they were deposited in their present *gisement*. The green grains of chlorite have been drifted into patches. Certain calcareous organisms are preserved, but many genera of mollusks only occur as casts in phosphate of lime. The phosphatic matter has been determined in its deposition by *animal* substances. There are two chief varieties of the "ordinary" nodules. The first are amorphous, or else finger-shaped; the second formed like a long cake rolled partially or wholly upon a stick. The surface of these two kinds of nodules is coriaceous and wrinkled, and they usually show marks of attachment to some foreign body. Certain species, clearly zoophytes, are converted into phosphatic nodules, and, when sections are made of these, they are found to show under the microscope structures and spicula allied to those of Alcyonaria. Slices of the *common* nodules show similar spicula, and occasionally reticular structure. When casts in plaster are made from *Alcyonium digitatum*, and coloured to resemble the nodules, the similarity in general form and structure of surface is very striking. The phosphate was probably segregated by the animal matter from its solution in water charged with carbonic acid, which is a known solvent of the phosphate; an analysis of the matrix has proved that phosphate of lime is appreciably present in it. The author doubted the derivation of the nodules from the denudation of the subjacent Gault, and exhibited a collection of these to show that they were distinguished by more stunted growth.

The deposit was on the whole considered to represent the thin band with similar fossils at the base of the Chloritic Marl, as seen in the west of England, in which district it is underlain by the true arenaceous Greensand. The absence of the true Greensand was attributed to the intervention of the old palæozoic axis of the London area; and it was finally suggested that a similar axis might stretch from Leicestershire to Harwich, causing the change in character of the Lower Cretaceous beds between Cambridgeshire and Norfolk.

3. "Some Observations on the Upper Greensand Formation of Cambridge." By W. Johnston Sollas, Esq., Assoc. Royal School of Mines, London. Communicated by the Rev. T. G. Bonney, M.A., F.G.S.

The Greensand Formation consists around Cambridge of a Chalk marl containing harder portions of a different nature disseminated throughout it, these are separated from the Chalk Marl by levigation, and sorted by sifting into larger bodies, consisting almost entirely of the so-called "coprolites," and smaller bodies—the so-called "Greensand." The author gave a general account of his conclusions regarding the "coprolites," reserving details for a future communication. Of all the facts the most obvious is the connexion between presence of "coprolite," and former existence of organic matter; when coprolite is found incrusting a bone or other fossil, it is precisely on those parts where animal matter adhered most abundantly. Instances were cited, as in *Palæocorystes*, where the absence of animal matter on the back of the carapace is marked by an absence of phosphatic incrustation; while the sternal side, where animal matter could easily escape, is often altogether embedded in "coprolite." Coprolites are the fossilization of organic matter derived from very various sources. In many cases they owe their origin to sponges, almost certainly so in the case of cylindrical coprolites perforated by a cylindrical cavity, now filled up with Chalk Marl; other forms have an *allied* origin. Thus coprolites are the flints of the Gault. The Greensand is a mixture of calcareous, siliceous, and dark-coloured grains of uncertain chemical composition. The calcareous grains consist of sponge spicules, minute shells, fragments and prisms of shell substance, bivalve entomostraca, microsopic corals, minute echinoderm species, polyzoa, and foraminifera. A list was given of the Foraminifera, the abundant occurrence of *Lagena* here being particularly noticed, as, with the exception of *L. apiculata*, mentioned by Reuss, the genus had not before been noticed below the Maestricht Chalk. The siliceous grains consist of fragments of various rocks, some of volcanic origin. The dark coloured grains are coprolitic *débris* and true green grains. The green grains are almost all casts of Foraminifera, derived chiefly from *Bulimina*; others are derived from *Lituola, Rotalina, Globigerina,* and other forms. Some green grains of exactly the same nature had been found by the author in the siliceous sand of Blackdown.

Discussion.—Prof. Phillips was glad that his casual remark had produced such satisfactory results as the paper he had heard. It was satisfactory to find that the bulk of the phosphatic nodules exhibited such marked traces of an organic origin. Though he had to some extent been prepared for this, it appeared that the view might be extended much further than would at first sight have been anticipated. He drew an analogy between the preservation of the forms of sponges in their silicified fossils with that of the soft organic bodies in the Greensand by phosphatic matter. In such case the surrounding water contained a large amount of either flint or phosphate of lime, which was segregated and accumulated round certain centres or nuclei.

Prof. Ramsay inquired from what sources the abundance of phosphatic matter requisite for the production of these fossils could have been derived. In such thin strata, which seemed to indicate a transition from a land to a marine surface, it was a matter of great difficulty to his mind to account for so great an abundance of phosphatic matter.

Mr. Godwin-Austen remarked that phosphoric acid was largely present throughout all water, and instanced the present seas, where, as on the Newfoundland banks, fish existed in enormous quantities, and no doubt also phosphatic matter. The Cambridge beds, though so rich, were by no means unique of their kind. He referred to a paper communicated some years ago to the Society by Mr. Payne, as affording many interesting particulars with regard to such beds. He considered that much of the phosphate attaching to decaying animal matter might have been derived from comminuted coprolitic deposits floating in the water.

The Rev. T. G. Bonney remembered a fact quoted by the late Dr. Mantell as to the large quantities of dead Mollusca which had been observed floating down some of the American rivers, and which had been regarded as a plentiful source of phosphatic matter. Small fishes might also have furnished a considerable quantity, and their value as manure was recognized at the present day. With regard to the nodules being Alcyonaria or sponges, he observed that what spicules he had seen appeared more like those of sponges. He agreed with Mr. Sollas as to the Foraminiferal origin of many of the green grains. He did not agree with Mr. Fisher in attributing all the nodules to the bed in which they were found, but thought that a considerable portion might be referred to the upper part of the Gault. In proof of the washing the Gault near Cambridge had undergone, he mentioned the occurrence there of a number of boulders of rocks quite foreign to the district.

Mr. J. F. Walker thought that most of the fossils of the phosphatic band at the base of the Chalk-marl were derived from the Gault, whilst the bed differed from Chalk only by green grains becoming gradually more abundant. The fossils were generally much waterworn, the characteristic fossils of the Warminster Greensand were absent, and the most abundant fossils were all of Gault species. It seemed that wherever these accumulations of phosphatic matter occurred, denudation had taken place, and that they were the residuary heavy materials of a large thickness of rock. This might also be observed in the Upware and Potton beds.

Mr. Whitaker observed that the Upper Greensand thinned out as much to the south as to the north of London. He inquired as to the alleged abundance of phosphate of lime in the upper part of the Gault. He doubted whether the thin band at Cambridge could represent the great thickness of Upper Greensand which was to be found in some other districts. He regarded it rather as a gradual passage into Chalk, though the line of demarcation was evident on the Gault. Though agreeing with Mr. Walker as to some of the fossils having been derived from the Gault, he could not regard them all as having come from that source.

Mr. Meyer thought that the Greensand had always been absent in the Cambridge district, and mentioned the occurrence of a bed of much the same character as that in question at Niton in the Isle of Wight.

Mr. Forbes pointed out that the amount of phosphatic matter in fishes was so small that it was difficult to assign such an abundance as that described to this source. In a mass of limestone composed of shells, he could find but 2 per cent. of phosphate of lime. Even with true coprolites, he thought that they had become richer in phosphate since their first deposit; but whence it was derived he would not pretend to say. He thought this question of derivation still open.

Prof. Morris mentioned the occurrence of similar deposits near Wissant, on the coast of France, and near Calne, in Wiltshire. He called attention to the extremely quiet nature of the sea in which the phosphatic bed been deposited, and observed on the existence in recent times on certain sea-shores of ooze containing a large amount of phosphatic matter.

Mr. Fisher, in reply, stated that he had in his paper but slightly touched on the sources of derivation of the phosphate of lime; but as to the possibility of that substance being localized and derived in large quantity from fish, he pointed out that the principal manure of modern times, guano, was derived from this source. He alluded to the possibility of some process of dialysis having contributed to the segregation of the phosphate. He disputed the identity of the nodules in the Gault and in the chloritic marl at Cambridge. As to the character of the fossils, he regarded it as the same as that to be found in a thin band at the base of the Chalk in parts of Hants and Dorset.

Mr. Sollas had examined sections of the fossils from the Cambridge beds under the microscope, but had failed to find the canals or tuberculated spicules characteristic of Alcyonaria. He had, however, in the sand found numerous indisputable sponge spicules. He had, moreover, found in sections of the coprolites spicules such as were regarded by Dr. Bowerbank as characteristic of sponges. He hoped however, to recur to the subject. Both Mr. Fisher and himself concurred in removing these nodules from the category of concretions, and placing them under the head of organic fossils. The transported blocks in the beds bear evidence of glacial action, and he considered had been brought from Scotland or Scandinavia. He thought that some portion of the phosphatic matter was derived from the decomposition of the volcanic rocks north of Lammermuir, which were rich in this substance, and of which rocks he had found fragments near Cambridge. He considered that, under certain circumstances, the phosphatic matter present in water would combine with animal and mineral matter, and hoped at some future time to offer some remarks on this subject to the Society.

Royal Geological Society of Ireland.—June 12, 1872.—Prof. Macalister, M.D., President, in the Chair.

Prof. Hull, F.R.S., exhibited two slices of Chalk from County Antrim, showing under the microscope its essentially Foraminiferous structure. On comparing the forms with those in Ehrenberg's *Mikrogeologie*, Prof. Traquair and the author were able to identify at least five genera, namely *Rotalia, Textularia, Planulina, Nodosaria,* and *Globigerina*—this last named being, as in the Atlantic mud, the most abundant; and, in fact, constituting the greater part of the mass of the rock. The cross-section of the spine of an *Echinus*, and other forms of doubtful affinities, were also observed. The shells were nearly all preserved in calcite, and bound together by impalpable carbonate of lime. The slices were made by Mr. Jordan, of the Museum of Practical Geology.

Mr. Hull called attention to the fact that the Foraminifera of the Chalk of the north of Ireland had scarcely received any attention from palæontologists. This, he considered, might be partly attributed to the unusually indurated character of the stone, which rendered it almost impossible to extract Foraminifers by washing. This quality, however, was favourable to the preparation of thin slices for microscopic examination; and Professor Rupert Jones had kindly undertaken to examine slices of the Antrim Chalk for comparison with those forms now under investigation by himself and Mr. Parker.

CORRESPONDENCE.

DRIFT DEPOSITS OF IRELAND.

Sir,—I trust you will give me space to refer to Mr. Kinahan's paper on the Middle Drift-gravels of Ireland in the current number of the Geol. Mag. I should not have noticed it at all, but that some of your readers might have supposed that I admitted the correctness of Mr. Kinahan's statement, that my section of the Drift-deposits in Killiney Bay was incorrect; or that there is no Upper Boulder-clay there. On the contrary, I maintain that my section and description (Vol. VIII., p. 294) gives a faithful representation of the succession and arrangement of the beds, showing a true upper Boulder-clay near the Martello Tower, and Ballybrack Station, with a general basin-like arrangement of the beds.

Beyond the point where my section terminates, in the direction of Bray, there are, as Mr. Kinahan states, certain local irregularities, the exact nature of which a very hasty visit has not yet enabled me to determine. This part of the section I had not visited at the time I wrote my paper. But whatever their nature, they cannot invalidate the general succession of the Drift-deposits, as stated both by Professor Harkness and myself to be synchronous on both sides of the Channel. Mr. Kinahan cites Professor Harkness's name in support of his statement that there is no Upper Boulder-clay in Killiney Bay. I believe, however, Professor Harkness has not visited this section since my paper was published, and certainly not in my company; otherwise his opinion might have been different.

Geological Survey Office, Edward Hull.
Dublin, June 17, 1872.

AGE OF AURIFEROUS DEPOSITS OF AUSTRALIA.

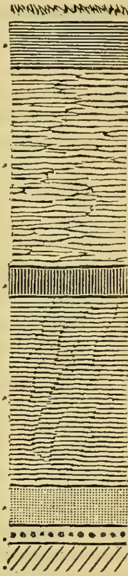
Sir,—I am able to communicate some information relating to an important discovery lately made by the gold miners now working at the "Welcome Rush," about four miles south of Glenorchy, on the river Wimmera, which I have no doubt will be regarded with interest by your readers.

Up to the present time the geologist has had to determine the age of the auriferous drifts of this Colony on such doubtful evidence only as is presented by the lithological character and position of the beds. It is true that fossil bones of marsupials have been found in very recent accumulations covering *wash-dirt*, and in some of the deep *leads* numerous fossil fruits and impressions of leaves, but I think I am correct in stating that no *marine fossils* have been discovered anywhere in Tertiary strata containing gold.

Marine fossils have been found lately at the "Welcome Rush;" and though they cannot be regarded as throwing much light on the age of the deep auriferous deposits which occur at Ballaarat and Smythesdale, they are nevertheless highly interesting.

The diggings at Welcome Rush encroach on the Murray Tertiaries, which occupy an area exceeding 26,000 square miles; and the results of the labours of the miners show that these in this immense tract cover auriferous *wash-dirt*, but whether in all parts sufficiently rich to remunerate the workmen it is at present impossible to say.

The following is a section of the strata at Welcome Rush:—



			ft.	in.
1.	Surface soil and yellow clay	(1)	4	0
2.	Ferruginous conglomerate	(2)	34	0
3.	Brown iron ore with shells	(3)	2	0
4.	Very hard ferruginous conglomerate	(4)	34	0
5.	Very fine white sand	(5)	3	0
6.	Auriferous wash-dirt	(6)	1	0
7.	Red Rock (Silurian)	(7)	78	0

This section and specimens of rock containing casts of shells were sent to me by Mr. Bernhard Smith, the warden of the gold field.

As soon as I received the specimens, I placed them in the hands of Professor McCoy, who has been good enough to give me the following report respecting them. He says, "The rock mass from the Wimmera, resting on the gold drifts, submitted for my opinion as to its age, and whether marine or freshwater, has been examined by me as far as the imperfect nature of the fossils will allow. I can state that the fossils are certainly marine; and I have no doubt of the older Pliocene Tertiary age. Species of *Turritella, Terebra*, and apparently *Turbo*, and two genera of bivalves, apparently *Arca* and *Mactra*, but requiring more perfect specimens to determine, are common. I do not think this evidence clashes with my old suggestion that the gold drifts of this Colony were of the age of the Mammaliferous Crag, as in Russia, based on the jaw of *Phascolomys pliocenus* (McCoy), found in the cement at Dunolly, as this deposit in Europe contains marine, generally like this Wimmera rock, littoral genera of Mollusca with the bones of terrestrial mammals."

Mr. Smith informs me that it is now very difficult to get any rock containing shells from the spoil-heaps, but I have asked him to employ some of the miners in putting up a stage in one of the shafts whence they can make a *drive* into the shell-bed and collect rock-masses enclosing these interesting remains. All the specimens will of course be submitted to Professor McCoy for examination, and in due time, if I am able to get specimens, the results will be communicated to you. R. Brough-Smyth.

Flemington, Victoria, 20*th April*, 1872.

THE

GEOLOGICAL MAGAZINE.

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ORIGINAL ARTICLES.

I.—Notice of a Fossil Hydractinia from the Coralline Crag.

By Prof. George James Allman, M.D., F.R.S., etc.

AMONG the very few known instances of fossil hydroids, the genus *Hydractinia* must be included. Under the name of *Cellepora echinata,* M. Michelin has described a fossil from the Subapennine group of Asti, and from the Superior Fallunian of Bordeaux and Dax (Michelin, Icon. Zooph., p. 74, pl. xv., fig. 4). M. Fischer has drawn attention to the fact, that the *Cellepora echinata* of Michelin is really a *Hydractinia* encrusting a *Murex* or a *Nassa,* while he has himself added another fossil *Hydractinia* from the Upper Greensand of Mans (Fischer, Bull. de la Soc. Géol. de France, 2^{me} sér. t. xxiv., p. 689). This he found in the collection of M. Alc. d'Orbigny, where it encrusted numerous specimens of *Natica tuberculata,* d'Orbig., from that formation. M. Fischer has assigned to this species the name of *Hydractina cretacea,* while to Michelin's species he has given that of *Hydractina Michelini.*

To the two examples thus noticed by Michelin and Fischer, I am enabled to add a third from the Coralline Crag of Suffolk. It occurs among some Coralline Crag fossils in the collection of the British Museum. It was found encrusting two specimens of *Purpura lapillus,* one from Orford, and the other from Gedgrave, in Suffolk. It covers with a continuous crust the shell over which it spreads, and has a minutely alveolar structure, with its surface thickly set with short blunt spines. The original chitine of the common basal expansion is entirely replaced by carbonate of lime. There cannot be the slightest doubt of this fossil being a true *Hydractinia,* and indeed it is impossible to find any characters which can separate it from the living *Hydractinia echinata.* From the mere fossilized basis, however, which is, of course, all that has come down to us, we should not be justified in asserting its identity with the living hydroid.

M. Fischer gives no description by which his own hydroid may be specifically distinguished from that of M. Michelin, though he regards the two as specifically distinct, and assigns to them distinguishing names. Indeed it is highly probable that no zoological characters of diagnostic value can be detected sufficient to distinguish them from one another, or from the Coralline Crag fossil here noticed, or even from our living *Hydractinia echinata ;* and the only tangible distinction between the four hydroids is thus a purely chronological one. We should not however on this account be entitled to regard them all as representing a single species; for it is by far the most likely that true zoological characters would be found if an opportunity existed of examining in the fossils the soft parts now entirely lost, more especially when we bear in mind that these fossils belong to periods separated from one another by such long intervals of time as those which intervene between the Cretaceous, Miocene, Pliocene, and existing epochs.

Under these circumstances, there is no reason against assigning also to the Coralline Crag species a distinguishing name; and though no available zoological characters can be found on which a diagnosis may be based, the geological position of the hydroid may conveniently suggest the purely provisional designation of *Hydractinia pliocena.*

II.—The Permian Beds of Yorkshire.

By Joseph Lucas, F.G.S.,

of the Geological Survey of England and Wales.

In the March number of the Geological Magazine, Mr. A. H. Green observes that it is difficult to account for the supply of salts to the Permian Sea. For the iron, he calls in the aid of mineral springs produced by volcanic action; but for the lime and magnesia, streams flowing into the sea holding in solution bicarbonate of lime and sulphate of magnesia.

Now, at present, the Magnesian Limestone rests on Coal-measures, Millstone-grit, and nearly touches Yoredale Limestones, near the Swale. The Millstone-grit alone might furnish iron enough,[1] to say nothing of other bordering formations. All over its surface now thousands of chalybeate or ferruginous springs break out, some of them most copiously charged with iron. The whole system is replete with iron,[2] as appears from the quantity which is seen at the surface in the form of oxide. It is quite the exception to find sandstones unstained by oxide of iron, and in a less degree the same is true of the shales which often contain beds of ironstone. Certain beds are so full of it that when seen in section they are of the brightest red. One such I have traced for more than fifteen miles. It is a coarse grit full of cavities containing an ochreous powder, and sometimes red felspar. When ploughed, it forms a silky, bright-red soil. It also contains fragments of Encrinites and shells. Thus there is a bed in the Millstone-grit series, which, when free from drift, colours fields quite as bright a red as the Magnesian Limestone does, and whose existence implies an amount of concentration scarcely inferior to that required for the formation of red beds in the New Red Sandstone. From its conspicuous colour it

[1] Mr. David Forbes says that "many beds, for instance the Gault, contain more iron than those which are now red, though they may be grey or blue."

[2] In the form of bisulphide and carbonate. I have found iron pyrites in shales in Nidderdale, and bands and nodular beds of clay ironstone in many places.

gives the name of Red Scar to several scars on Great Whernside. I am told that the occasional outbreak of a ferruginous spring from coal-workings will kill the river fish for miles; so that if nothing but iron had been precipitated in the Permian Sea, the effect on the fauna would have been the same. Sulphureous springs also break out from the Millstone-grit, one at Aldfield may be perceived for a quarter of a mile, where there is a draught along the valley in which it lies, and the Carboniferous Limestone contains magnesia.

As regards the lime, it is confessedly not derived from organisms that lived in the Permian Sea, and the limestone being over a very large area uniformly thinly and evenly bedded seems to have been deposited tranquilly in still waters. Little rivers flowing from Carboniferous hills, cutting through Millstone-grit to the Yoredale limestones, would bring with them supplies of lime, magnesia, and iron, in quantities practically without limit. I cannot see that anything more is required to suit the facts of the case. From these sources and the Coal-measures would then be derived the principal part of the sediments deposited in the Permian basin. Not knowing how far the question is considered to be settled, I do not take it for granted that the Pennine anticlinal ridge was formed before the deposition of the Permian beds, but I think the evidence is very strongly in favour of such a probability. For through the Millstone-grit rocks from Wharfedale northwards, run many anticlinals approximately E. and W., and many of these pass under the undisturbed Magnesian Limestone; several large faults do the same; the base of the limestone is bounded by a wonderfully regular line, and is not sinuous or broken up into outliers opposite the high ground north of Ripon. Not a single outlier occurs anywhere on the chain, and not one creeps even a little distance up the slope. From Leeds northwards, as far as Bedale, the pale yellow limestone rests on bare Millstone-grit, with in one or two places the most trivial exceptions. All these facts seem to point to the same conclusion, *viz.* :—that a limit of the basin is reached, and approximately represented by the present base of the Magnesian Limestone, at least for that distance. For the absence of sediments below the lowest limestone during that space seems to point to an overlap of the limestone over sediments previously deposited, whereby the limestone was brought to rest against the bare sides of the basin. It now dips east about 6°, some 2° or 3° of which may have been original deposition.

Two other facts seem also to favour the idea that the Pennine anticlinal was formed before the deposition of the Permian beds; firstly, that fragments of Carboniferous Limestone do occur [1] on the west side in the basin below the Magnesian Limestone, and secondly, that on the east side in Yorkshire and Durham they do not. For on the steep West side of the anticlinal, the Carboniferous Limestone must have been exposed to allow those fragments to appear; and on the East, for some distance at least, it was probably covered with a thick series of grits and shales. I am aware that the concretionary nodules in Durham may be formed round pebbles of Carboniferous

[1] Ramsay. Pretriassic Red Rocks. Proc. Geol. Soc., vol. xxvii., p. 246.

Limestone, but, even if they are, there is no reason why *some* limestone pebbles should not have been transported into the basin, especially as near the Swale nearly the whole of the Millstone-grit covering was cut through before the deposition of the Permian beds. So far from volcanoes occurring nearer than Scotland to this area, I think the evidence seems rather to favour the idea of a continuous subsidence having taken place here during the deposition of the Permian beds. For the quicksands mentioned by Mr. Green, being excessively current bedded, point to the close neighbourhood of land, inasmuch as in an inland basin not subject to tides one would not expect great irregularity in the bedding when the current had proceeded some distance out. After the long interval between Leeds and Crakehall, where there are no sediments except here and there about five feet of flaggy and marly beds, the Marl Slate [1] of Durham comes on. At East Thickley, where it is 30ft. thick, it contains "fish of genera, which, from having all been found in Carboniferous strata, probably lived near the shore." Now as on these quicksands, bare Millstone-grit rocks from Leeds to Crakehall (presumably above water when the quicksands and Marl Slate were deposited), and Marl Slate of Durham there now lies a vast thickness of evenly thin bedded limestones and marls, this fact seems to require one of two things, either a continuous subsidence or a vast increase in the supply of water to the basin, or both; for up through the whole series every part seems more like a shallow than a deep water deposit, and in the highest limestone itself, "some of the beds are ripple marked, and Mr. King imagines that the absence of corals and the character of the shells indicate shallow water." In Scotland, where volcanoes were active, we are clearly on the limits of the basin, for in Dumfriesshire abundant reptilian footprints have been found in sandstones.

Thus it seems to me that if Carboniferous rocks formed part of the coast land of the Permian Sea, there was an inexhaustible supply of all the materials which now form the Permian beds. The Carboniferous Limestone itself is sometimes Magnesian, as in the case of the dun lime, and with regard to the peculiar bituminous smell of the Magnesian Limestone when struck, I can only say that it is far from being peculiar, and that Carboniferous Limestone very often smells exactly the same.

It seems also unlikely that active volcanoes existed nearer to this area than where they have been proved in Scotland, since the iron may have been supplied without volcanic springs, direct from the Carboniferous formations, as well as from the older granitic and other metamorphic rocks from which the Carboniferous strata were themselves formed, and supplied with iron.

The Purple Colour.

From Mr. Ward's paper, descriptive of the Plompton grits,[2] it is

[1] "The fish of the Marl Slate have generically strong affinities with those of Carboniferous age, some of which were undoubtedly truly marine, while others certainly penetrated shallow lagoons bordered by peaty flats." Ramsay, Quart. Journ. Geol. Soc., vol. xxvii., p. 248.

[2] Quart. Journ. Geol. Soc., vol. xxv., p. 291.

not made to appear how local the purple colouring really is. Mr. Ward remarks that red grits are not unfrequent in the Millstone-grit series. He admits that the colour of the Plompton grit is by no means constant, and assigns as its southern limit the neighbourhood of the Wharfe, near Collingham. I subjoin a list of sections in grit immediately below the base of the Magnesian Limestone from six miles north-east of Leeds northwards. Those which are good clean sections, where limestone is actually seen resting on grit, are marked with a star*.

South of the Wharfe.

1. Hetchell Wood, where limestone rests on yellow grit.
2. Hell Pot Wood, where limestone rests on yellow grit.
3. *Rigton, in road, where limestone rests on yellow sandstone.
4. Wetherby Lane, where limestone rests on yellow grit.
5. Compton, where limestone rests on yellow grit.
6. *Quarry, near Collingham Cottage, where pale yellow limestone rests on massive white grit.
7. Langwith Sulphur Spa, where limestone rests on white sandstone and blue shale.
8. *East Keswick, in road, where limestone rests on hard white and yellow sandstone.
9. Millgate Quarry, where limestone rests on white and red micaceous sandstone.
10. River Wharfe, near Keswick Moor Farm, white and yellowish sandstone.

Of these ten places, limestone is only seen actually resting on grit in three, but the others are separated by at most only a few feet from spots at which limestone is seen above, or very near. In every case the colour of the sandstones is perfectly ordinary and not coloured in the least degree, except in Millgate Quarry, where it is *reddish*, and that to an amount vastly exceeded in beds lying far in the heart of the Millstone-grit country. Below the white sandstone, at East Keswick, upon which pale yellow limestone is seen to rest, there is a thin band of purplish shale; but the great section in shale in the bank opposite Bolton Abbey is of the richest purple, many miles from the influence of any causes beyond those that are embodied in itself; and had this purple colour in the shale at East Keswick been derived from above, the sandstone resting upon it and below the limestone ought to have been purple too. Mr. Ward quotes another case far from the limestone.[1] I failed to discover any purple grit south of the Wharfe.

North of the Wharfe.

1. *Newsome Bridge Quarry, where limestone rests on "white grit, with no trace of red or purple colouration."
2. *St. Helen's Quarry, where yellow limestone rests on five feet of red marl which it overlaps at either end of the quarry, and this again rests on coarse purple grit.

The Knaresborough sections I have not seen, nor those of Scarah and South Stainley, but they all seem to be in the same bed as the red grit of Plompton and Sicklinghall, the most southerly point at which I have observed coloured grit. The range of the phenomenon does not extend as far as Ripon. At Fountains Abbey there is red grit seen, but this is not seen to lie immediately below the lime-

[1] Quart. Journn. Geol. Soc., vol. xxv., p. 295.

stone. This too is in the same bed, which, as far west as eight miles west of Harrogate, near Fewston, is conspicuously red, coarse, and partly unconsolidated. There the colour is quite its own.

North of Ripon the base of the limestone is seen near

1. Galphay Bridge, over the Laver, where it is separated from the underlying uncoloured coarse grit by a few feet of Permian flaggy sandstones and a few intermediate bands of red and grey marls.
2. Near Quarry House, Sleningford, pale yellow limestone is separated from the uncoloured grits below by a few feet of blue flaggy limestones with *Producta horrida*.
3. At Crakehall High Mill, pale yellow limestone passes over a few feet of pale yellow magnesian conglomerate, which rests on grey marl, three feet, and that on red marl of which only two feet were seen. Here the colour is not derived from the limestone, as the grey marl is the upper one.

Thus of fifteen sections along the base of the Magnesian Limestone, for a distance of about thirty-two miles measured straight, *not one* exhibits purple grit immediately under the Magnesian Limestone. Four clean sections show limestone resting on uncoloured grits. In one case only, where purple grit is seen in the same quarry as Magnesian Limestone, there is an intermediate bed of red marl. All the other sections show uncoloured beds close below the limestone.

Under any circumstances, only one and the same bed is found to be purple, and this one in the limited area over which it maintains its colour with any constancy is frequently of a bright red. Far down in the Millstone-grits there is another thin but very often bright red or ochreous bed, which I have mentioned before as the Redscar grit, and Mr. Ward quotes another under Bradford Moor.

The purple colour in question is so exactly that of the Permian marls, that taking into account the number of times that the limestone has failed to impart any colour to the beds below it, and that it cannot be proved to have done so in one single instance, I cannot avoid the conclusion that the date at which the Plompton grit received its purple colour was during the deposition of the earliest red sediments below the limestone, and that the carbonate of iron sank into the Plompton grit from Permian waters, and not from subsequent infiltration from colourless limestone. In no section where I have seen weathered Magnesian Limestone in quarries has it been red, which the peroxidation of its iron should have made it, if Mr. Ward's supposition were true. Subsequent overlap may have brought the limestone to rest against uncoloured Carboniferous rocks.

I would extend the remark to all rocks which underlie red rocks, and are stained red by infiltration, that the infiltration took place when the earliest red beds lying upon them were being deposited, and that the vehicle was the same as that which conveyed the colouring matter into the beds above. Thus if sediments are about to be thrown down in waters charged with carbonate of iron upon a bed of porous rocks, I see nothing to prevent carbonate of iron from being carried into the latter as well as into the former ; when under exposure to favourable circumstances both would appear red. In the explanation of the quarter sheet, 93 SW.,[1] the lower limestone is

[1] Mems. of the Geol. Surv. of Engand and Wales.

not described as having any red tint. It does not colour the fields red, when free from drift, but pale yellow fragments lie thick upon the soil. The marls above form red soil, and the upper limestone which "contains little or no magnesia" "has often a red tint." If both these beds contain iron in the same form, why is the upper one peroxidized and the lower one not so? Were Mr. Ward's explanation the true one, the lower limestone ought certainly, at least here and there, to be reddish; but, as before stated, neither this bed, nor the grits on which it is seen to rest in clean section, are at all red, where I have seen them, except in the one case where a bed of red marl lay between the grit and limestone.

III.—Notes on Fossil Sponges.

By Harvey B. Holl, M.D., F.G.S.

(PART II.)

(*Continued from page* 315.)

III. Pictet converted D'Orbigny's families into tribes, and introduced some additional genera created by Giebel, King, etc.; and, except in the description of new genera and species by Reuss, Roemer, Salter, Eichwald and others, the subject remained very much where D'Orbigny left it until M. de Fromentelle proposed a new arrangement, based upon what he terms the "organs which serve for the nutrition of the sponge,"—viz., the tubule, oscules, pores, etc. Like D'Orbigny, he divides the sponges into two orders: 1st, the Spongiaria, which comprises only recent genera; and, 2nd, the Spongitaria, which contains all the fossil genera, with the exception of the doubtful group, the Clionidæ. The second order is further divided into three sub-orders: 1, those sponges which have one or more tubules (the *Spongitaria tubulosa*); 2, those that have oscules, but no tubule (*Spongitaria osculata*); and 3, those that have neither tubule nor oscules (*Spongitaria porosa*). Each of these sub-orders is further divided thus: the tubular sponges into those in which the tubule is solitary, and those in which it is grouped, and also into those with oscules and those without oscules. The oscular sponges are similarly subdivided, according to form, disposition of the oscules, and presence or absence of an epitheca. Lastly, the porous sponges are divided into those that are more or less regularly cup-shaped, and those that assume some other form.

In this arrangement no importance is attached to the nature of the sponge-tissue as a character. In fact, M. de Fromentelle states that he considers it to have "a value altogether secondary, for it is not the form or composition of the skeleton which determines the functions, but the functions themselves which give to the animal the particular form which characterizes it."[1] It is not necessary, however, here to discuss this question, further than to observe, that the power which the sponge has to secrete a siliceous spicular framework in one case, or a fibrous rete in another, implies

[1] *l. c.*, p. 17.

an inherent difference in the nature of the animal, however much they may resemble one another in external character. It will be desirable, therefore, to consider the value of these organs for a moment before proceeding further, and in so doing it will be well to turn to the living sponges for aid.

1. *Form.*—As already observed, form, taken alone, is of little value even as a specific character, for whether it be cup-shaped, tubular, or polymorphous, it is not distinctive, inasmuch as it is common to sponges widely differing in all other characters, and indeed, as remarked by Dr. Bowerbank, trusting too implicitly to outward configuration has led to the placing of spicular and fibrous sponges side by side in the same genus. Moreover, the form varies greatly at different periods in the growth of the same individual; and even in the cup-shaped sponges, commonly the most constant as regards this character, there is a wide difference in the figure of the old and young individuals of the same species. Hence it is that we know so little of the young condition of many of the fossil sponges, which are not recognized as such, but are regarded, for the most part, as distinct species.

A circumstance which illustrates how the form of the sponge is liable to be governed by accident is mentioned by Dr. Bowerbank in speaking of their reproduction, and is so suggestive that I quote his own words: "On a fragment of a bivalve-shell 20 or 30 sponge-gemmules had located themselves, the largest of which did not exceed $\frac{1}{300}$ of an inch in diameter, and their distance apart is about equal to their diameter. In their present state," says Dr. Bowerbank, "it is evident that they are separate developments; and it is equally evident that a slightly further amount of extension would have caused them to merge into one comparatively large flat surface of sponge. We see, by this instance, that a sponge is not always developed from a single ovum or gemmule, but, on the contrary, that many ova or gemmules are often concerned in the production of one large individual; and this fact may probably account for the comparatively very few small sponges that are found."[1] Thus the form of the sponge may be modified, in some instances, by the number of gemmules or ova that may happen to be grouped together, for it is well known that sponges of the same species readily unite when in contact.

It is necessary to bear these facts in view, for in most of the higher groups of life, whether living or extinct, variation in form is restricted to within very narrow limits, and therefore it is one of the most important characters we possess in the determination of the species. Nevertheless, even in the sponges it is not without a value, for in certain fossil genera the more matured individuals appear to be tolerably constant in this respect, as for instance the *Ventriculites*, *Ischadites*, *Guettardia*, etc., but at the same time the young condition of these genera are unknown to us, or if so have been regarded probably as altogether distinct; the youngest indi-

[1] *l. c.*, p. 146.

viduals which are recognizable with certainty having already attained, comparatively speaking, considerable dimensions.

2. *The Cloaca.*—The cloaca or tubule may be either isolated or grouped. It may extend nearly the entire length of the sponge or only a part of the way, as in *Siphonia.* It is distinguished from the oscules by its larger size, the evenness of its walls and often by the orifices of the excurrent canals, or oscules, opening into it. The cloaca is essentially an ejaculatory passage, and in those fistulous sponges having oscules on the outer surface, these latter are the orifices of incurrent, not of excurrent canals, and in the living sponges are sometimes protected by a diaphragm formed of long simple slightly curved (acerate) spicula, but which would necessarily be lost in the fossil.

In the young sponge the cloaca is sometimes absent, as is often the case in the earlier period in the growth of *Siphonia pyriformis,* in which the place of the cloaca is occasionally found occupied by a group of small tubules, which ultimately either becomes converted into one large fistulous opening by the breaking down of the intervening tissue, or is surmounted by the true tubule. In its earlier condition, therefore, it presents the characters of *Jerea,* and only becomes converted into a veritable *Siphonia* as it approaches maturity.[1] On the other hand, in old fistulous sponges the margins of the cloaca sometimes break down and become fissured, and at length converted into an irregular cavity, in which it is difficult to recognize the characters of the original tubule.

3. *The Oscules.*—The oscules are the orifices of the incurrent and excurrent canals. By all authors who have written on the fossil sponges, however, they have been regarded solely in the light of ejaculatory openings, but the study of the recent species has enabled Dr. Bowerbank to ascertain that this is not the case, and that in the tubular and cyathiform sponges, those only which open into the cavities appertain to efferent canals; while those situated on the exterior lead into the canals which are destined to give passage to the incurrent streams of nutritive fluid. In all the tubular and cup-shaped sponges, therefore, their office may be inferred by their position. In the amorphous sponges they are scattered over the surface either singly or in groups, sometimes on mammillary elevations or ridges, sometimes in pits or depressions, and are probably ejaculatory orifices, imbibition taking place through the pores and interstices of the sponge skeleton. They are permanent organs, and vary greatly in size, proximity, and regularity in their distribution. Occasionally several grooves radiate from the margin of the oscule, and in other species there is no distinct orifice, but the grooves terminate internally in three or four small pores, which then supply the place of the single oscule; but even these are sometimes scarcely perceptible, as in the Silurian *Stromatopora* (*Stellispongia*) *constellata* (Hall). These stellate grooves or "*Sillons*" are not, however, physiologically distinct from the oscules; and the smaller grouped

[1] The *Jerea pyriformis* (Lamouroux) is perhaps a distinct species.

tubules, as for instance those in *Jerea* (*Polypothecia*) *dichotoma* (Benett), and *J. pyriformis* (Lamour.), etc., do not differ from oscules except in their greater length.

4. *The Pores.*—Besides the oscules, palæontological writers are in the habit of speaking of the pores. It must be understood, however, that by this term they designate not the temporary openings in the sarcode of the animal during imbibition, to which it is properly applied, but merely the interstices in the tissue of the skeleton in the dead sponge; for in the living state these interstices are more or less completely filled with the sarcode. In some sponges there are no orifices either of incurrent or excurrent canals that are distinguishable either by form, size, or position from the ordinary interstices of the sponge-tissue, the whole being formed of a nearly uniform rete; and in these cases the pores or interstices must supply the place of the larger orifices, although closed by the sarcode during the intervals of active inhalation and exhalation; moreover, in those sponges possessing well-marked incurrent orifices, it is still probable that the whole of the external surface is more or less an inhalent one, through the interspaces of the rete, according to the exigencies of the animal.

5. *The Epitheca.*—Among the fossil sponges some portion of the surface, especially externally towards the base, is frequently observed to be either without pores, or they are so minute as to be invisible, and the sponge then appears as though covered by a more or less smooth or slightly wrinkled membrane, which has been regarded by D'Orbigny, De Fromentelle, F. A. Roemer and others, as analogous to the epitheca of the *Zoantharia*; and the occurrence of this epitheca has been held to be an additional evidence of the stony nature of the sponge skeleton. When examined microscopically, by means of thin sections, however, it appears that this epitheca is due to the filling up of the interstices of the superficial parts of the sponge, which, in the situations in which it exists, is finer and more condensed than elsewhere.[1] This greater density at the surface may be seen in many recent sponges, the superficial portions of the tissues being closer and finer than that of the interior, which was formed during an earlier and more active period in the growth of the sponge. But either from having arrived at maturity, or at a period when the growth was temporarily arrested, for in some sponges the growth is intermittent, or, as appears sometimes to be the case, from some local cause, the tissue at the surface assumes a closer arrangement. Thus in the common *Halichondria panicea*, the surface over greater or lesser portions frequently presents a condensed appearance with scarcely any visible interspaces, the outer superficial portion being

[1] It is to this closer superficial portion of the tissue that M. Etallon has applied the name of périenchyma. "Dans certains cas," he observes, "lorsque le spongiaire parait avoir acquis tout son développement, le tissue devient plus fin, plus serré, recouvre toute la surface d'une couche plus ou moins épaisse et adhérente et donne au squelette un aspect différent de celui qu'il avait a l'époque de la croissance et qu'on peut toujours retrouver par des coupes ou par l'usure."—*Rayonne's du Corallien* (*Haut Jura*), p. 139; also *Sur la Classification des Spongiaires du Haut Jura*, p. 137.

made up of a densely matted layer of spicula placed for the most part parallel to the surface; and the same is true of many fibrous sponges, as shown by Dr. Bowerbank. In some of the fossil sponges a similar modification of the tissue at the surface appears to have obtained, especially in certain cup-shaped and cylindrical sponges, and in the calcareous fossils in which this has been the case, the interstices, from their extreme minuteness, are more or less filled with carbonate of lime. Thus a species of *Cupulospongia*, common in the gravel-pits of Farringdon, frequently presents on its interior a smooth surface, described by the late Daniel Sharp as a membrane.[1] But if a number of individuals of this species be examined, it will be observed that although it sometimes completely lines the interior of the cup, it more often occurs only in patches; and that, while some of the interstices are blocked up, there are others that remain open, and this not as the consequence of friction or weathering, but as the result of fossilization. It is, however, in some of the sponges of the Oolite that we see this infilling of the interstices most distinctly, in some of the cylindrical forms especially, the whole of the sponge, except its summit, appearing as though invested by a sheath, but which, were it really of the nature of a true epitheca, as in the *Zoantharia*, it would be difficult to comprehend how the functions of the animal were carried on.[2] It is more than probable that this structure is nothing more than the cast of the impression or mould of the outer surface of the sarcode of the sponge, perhaps slightly thickened, but it is not constantly present even in the same species. For example, there is a small cylindrical sponge, not unfrequent in the Coral Rag, at Bullington Green, near Oxford, in which more or less of this so-called epitheca is met with in some individuals, while the greater number show nothing of the kind. It appears, therefore, that the epitheca is sometimes only a result of

[1] Quart. Journ. Geol. Soc., vol. x., p. 196.

[2] It is not here necessary to discuss the question of a "dermal membrane," as this would of course perish with the sarcode, and about which, moreover, some difference of opinion appears to exist, the facility with which the pores open and close to admit or check the incurrent streams of water, and the readiness with which the sarcodal mass is repaired after injury, and unites on contact with that of another individual of the same species, are facts which have been held to militate against the possession of such a structure. That the supporting tissue, in certain recent species, becomes closer and is otherwise modified at the surface, is clearly ascertained (see Bowerbank. *Ecronemia acervous*, Bowerb., MSS., *l.c.*, p. 173, pl. 28, f. 355; also pp. 107, 108, pl. 20, f. 309 and 310; *Halichondria panicea*, Johnston, pl. 19, f. 303), and in some species there is a crusticular layer of embedded ovaries abounding in minute spicula (Bowerbank, *l.c.*, *Pachymatisma Johnstonia*, Bowerb., p. 172, pl. 27, f. 353; *Geodia Barretti*, Bowerb., MS., p. 169, pl. 28, f. 354) beneath the surface of the sarcode. There is likewise a sponge common on the coast at Tenby, in which, in some individuals, the base and for a little distance above it does appear, in the dried condition, to be invested by something like a membrane, which terminates upwards in a well-defined and thickened or slightly wrinkled margin; the kerato-spicular tissue of the sponge immediately beneath it is more densely reticulated than in other parts of the animal; but I was unable to satisfy myself that it constituted a true membrane as distinct from the sarcode. That this soft structure may, under favourable circumstances, so impress the mould of the fossil as to produce the appearance described as an epitheca, may be possible; but this is altogether different from the sclerotic sheath which invests the exterior in the *Zoantharia*.

fossilization, and is sometimes probably the cast of the outer surface of the sarcode which has left its impress on the mould; that it is absent in the earlier and growing stages of the sponge, and is not constantly present in the matured individuals of those species in which it occurs; and, moreover, that it sometimes results from the contact of foreign bodies, in consequence of the increased density of tissue which such bodies are apt to produce. Its value, therefore, even as a specific character, is not great.

Simple as De Fromentelle's arrangement may at first sight appear, it is open to the objection that it is based upon characters that are not always very constant or very well defined, and are liable to graduate from one into another. Moreover it unites in one genus or species individuals which, having a very close similarity in external appearance, are totally different in the organization of the skeleton, and, on the other hand, it separates others which, though differing in outward characters, are closely allied in their structural details; for, however great may be the similarity in form or disposition of the oscules, etc., the power to secrete a framework composed of spicula in one case, or entirely fibrous in another, appears to indicate a difference in the nature of the sarcodal mass of higer importance than mere outward configuration, which we know from the study of recent species is frequently subject to considerable variation, either from age, local peculiarities, or other circumstances. Thus, Dr. Bowerbank, in illustration of the amount of variation observable in the recent sponges, refers to our common British *Halichondria panicea*, which, when of small size, has the oscules "situated on the surface of the sponge, and are scarcely, if at all, elevated above the dermal surface; while in large specimens of the same species we find them collected in the inside of elongated tubular projections or common cloaca which vary from a few lines only in height and diameter to tubular projections several inches in height, with an internal diameter of half or three-quarters of an inch. When they attain such dimensions, their parieties are often of considerable thickness, and their external surface becomes an inhalent one, like the body of the sponge."[1]

IV.—About the same time that M. de Fromentelle's Memoir appeared in the Transactions of the Linnæan Society of Normandy, M. Etallon communicated to the Société Jurassienne some papers on the sponges of the Upper Jurassic rocks, in which he proposed a new arrangement of the species and genera, based on the structural details of the skeleton. As he treats only on those fossil sponges which belong to the Upper Jura, his classification is necessarily incomplete; but it is nevertheless sufficiently so to foreshadow his views on the subject generally. Like D'Orbigny, he regards the *Clionidæ* as horny sponges, and forms them into an order by themselves; while the testaceous sponges included in the *Petrospongidæ* of M. Pictet, he divides into two orders—1st, the *Dictyonocœlidæ* or spicule-bearing

[1] *l. c.*, p. 113. Here we have an example of an oscule passing into a cloaca as age advanced, and an amorphous sponge becoming a fistulous one.

sponges, and 2nd, the *Spongiaires vermiculés*, or true *Petrospongidæ*.[1]

With respect to the first of these groups, M. Etallon observes:—"There are among the testaceous sponges which do not enter into the family of *Petrospongidæ*, some that have their skeleton made up of little needle-shaped spicula, which are merely held together by the parenchyma or sarcode of the animal, and of which, in certain formations, we find the scattered remains; but in other species these needle-shaped spicula are always anastomosed so as to form little stars united together by the extremities of their rays." It is to this group that he gives the name of *Dictyonocœlidæ*, and he describes these stellate spicula as being formed by the enlargement of the two extremities of a slender cylindrical spicula, which thereby become cone-shaped at the end, and unite, by the circumference of their base, with neighbouring cones, to form a six-rayed spicula with a central nœud; and, in the centre of this knot or nœud, M. Etallon believes that there exists a cubic space which is subdivided by vertical and horizontal laminæ placed in the axis of the rays into eight chambers. There results from this arrangement a frame work composed of horizontal, vertical, and radiating rods, having a knot at their point of intersection, and this eight-chambered nœud may be regarded as standing in the place of the octohedral structure of Mr. Toulmin Smith.

While agreeing with M. Etallon that there are certain sponges constructed on a general plan of intersecting horizontal, vertical, and radiating rods, a plan, indeed, which still obtains at the present day, the writer is far from admitting that this is the ordinary plan on which the spicular sponges are organized, and he has entirely failed to detect any trace of that subdivision of the cavity of the nœud into the eight cubic chambers described by M. Etallon.[2] Moreover, the manner in which it is suggested that the skeleton is made up—for as its development cannot be traced in the fossil it can be nothing more than a suggestion—is altogether opposed to what we know of the growth of spicula in general; and the study of the recent siliceous and calcareous sponges gives no countenance to the supposition that radiating spicula are formed by the union of the rays. On the contrary, as observed by Dr. Bowerbank, "However closely the spicula may be brought into contact with each other, or with siliceous fibre, they do not appear to unite or anastomose, while fibre, whether siliceous or horny, always anastomoses when it comes into contact with parts of its own body, or of those of its own species."[3] The growth of the sponge-tissue is outwards, not interstitial, and the parts once formed and fully developed undergo no further change. Judging from analogy, the development of the spiculum always

[1] The *Clionidæ* are, however, only the accidental occupants of the cavities in which they are found, having located themselves in the excavations formed by Annelida and the terebrating mollusks. For the most part they are spicular sponges.

[2] In some stellate spicula, probably in all, at the point where the central canals of the rays unite in the nœud, there is an hexagonal space, as noticed by this author, but the appearance of vertical and horizontal laminæ are referable to an optical effect of light.

[3] *l. c.*, p. 5.

proceeds from the centre, and growth takes place by additions to the thickness of the rays and at the points, and the occurrence of radiate spicula in the same individual sponge of all sizes, from the matured condition down to extreme smallness, always preserving the radiate form, is entirely against the view of M. Etallon. If union ever takes place, it is probably the result of fossilization, in cases where the points of the rays are in contact, and it is then brought about probably either by adventitious deposit, or in the replacement of the original structure the mineral which has infilled the mould has run together.

Nevertheless the labours of M. Etallon are a move in the right direction, and it appears probable from his research that by a careful investigation of the structural details of the fossil sponges, it may be possible ultimately to arrive at results which may lead to an arrangement of the species and genera more suited to the requirements of the day than the artificial systems of D'Orbigny and De Fromentelle. The time, however, is probably not yet come for this to be attempted, the more especially as the arrangement of the recent species is far from being settled.[1]

V.—Two conclusions are suggested by the foregoing remarks:—1st, that the present state of the fossil sponges affords no certain indication of their condition during life; and 2nd, that in the differentiation of the genera and species, the same principles must be kept in view in the fossil as in the recent sponge. Some of the oldest fossil sponges were as highly organized apparently (if the term is admissible to these humble forms of life) as those of the present day, as for instance the *Protospongiæ* of the Lingula Flags and Ludlow Rocks,[2] the Silurian *Ischadites*, and the Devonian *Sphærospongia tesserata*. The *Protospongiæ*, in fact, belong to that general type of cyathiform sponges, formed of elongated vertical and

[1] These "Notes" were written in the year 1866.

[2] Two undescribed species of this genus occur in the Lower Ludlow rocks of Leintwardine, for one of which I propose the name of *P. Ludense*, and for the other *P. maculæformis*. In *P. Ludense* the sponge has the figure of a horn slightly curved, and attains a height of 10 or 12 inches, and a transverse diameter (in its compressed state) of 4 or 5 inches. It consists of vertical and transverse fibres, which intersect each other obliquely at the base, but become more or less horizontal as the sponge enlarges; it is not evident, however, whether these fibres were united at the points of intersection, or simply apposed. The fibres which emanate from the base ascend to the summit, but as the sponge enlarged other fibres became intercalated, and scattered stellate (four-rayed?) spicula occur in the interspaces. In all the specimens hitherto met with the sponge is completely flattened, but its original cup-shaped figure is shown in a specimen in the Ludlow Museum, in which a thin plate of compressed sediment which filled the cavity exhibits the fibres on either side; and in the *P. fenestralis* of the Lingula Flags, the same can be ascertained by making transverse sections, when the cut ends of the rods are shown ranged in parallel rows on either side of a lamina of the matrix which occupied the cavity, reduced to a mere plate by compression. The other species, *P. maculæformis*, occurs as semi-circular or semi-oval stains on the surface of the Lower Ludlow shales, about 1½ inches in height and an inch in transverse diameter. As in the former species, it consists of extremely delicate vertical and transverse fibres, with a few stellate spicula in the interspaces. So thin is the fossil that it might readily be mistaken for mere vegetable stains, unless the fibres are especially sought for with a magnifying glass, and its cup-shaped form is inferred only from the type to which the sponge evidently belongs.

horizontal rods or fibres, which become more abundant in the Oolitic and Cretaceous rocks, and have their representatives even in the present day. The *Amorphospongidæ* first make their appearance in the Silurian rocks, and occur more or less abundantly in the calcareous marine deposits of all the succeeding epochs; and species are still living in our present seas, for which, as far as external appearances are concerned, at any rate, it is difficult to find good distinctive characters. The cup-shaped and cylindrical forms of this group commence in the Devonian and Carboniferous Limestones, and in the *Mortiera vertebralis* (De Koninck),[1] we have a depressed form of the latter, which, in the Mountain Limestone (?) of India attained greater vertical development. There are recent forms which, to all appearance, are undistinguishable either in figure or in the texture of the rete, and the only appreciable difference that can exist must be in the structure of the fibre. *Siphonia pyriformis* is apparently a still living species, well-preserved specimens from Blackdown presenting no external character to distinguish them from the recent form, nor with certainty do its structural details. The Warminster specimens are seldom well preserved; but in the flints of the Chalk thin sections sometimes show the spicular structure of the cords, of which the skeleton of this sponge is chiefly composed.

All the fossil sponges, exclusive of those masses of scattered spicula found in the Mountain Limestone Chert of the Great Orme's Head, the Lias of Glamorganshire, or the flints of the Chalk, etc., appear to be capable of being arranged in four groups having a common character—viz. 1st, those in which the skeleton is built up mainly of fibres or elongated spicula, which cross each other more or less at right angles, but which, in the cylindrical forms of this group, assume in part a radiating arrangement; 2nd, those in which it is constituted of variously formed spicula, heterogeneously arranged; 3rd, those in which the skeleton consists of a rete, the cords of which are formed of spicula; and, 4th, those formed of a rete of fibres in which spicula, if present, were only accessory, and which, judging from the general structure of the fabric, were probably keratose or horny sponges. No doubt the first two groups trench upon each other, in so far that the rectangular structure is frequently accompanied by accessory stellate and other spicula; and the last two may be often difficult to differentiate, in consequence of the structure not being sufficiently well preserved. These, however, are difficulties which the palæontologist has to contend with constantly, and which it is his object, with time and opportunities, to remove. Many a fossil conchifer has been moved from genus to genus, until the structure of its hinge was ascertained; many a mollusk is still uncertain as regards its affinities to existing genera. But on their relation to existing genera and species, which can be arrived at only by patient inquiry into structural details microscopically, by means

[1] Placed doubtfully among the *Zoantharia*, by M. Edwards and Haime, but specimens of this fossil from the Great Orme's Head, better preserved than De Koninck's types, now in the British Museum, enable the author to assign them a place among the sponges.

of thin sections or otherwise, can the differentiation of the fossil Spongiadæ be satisfactorily made. Occasionally the structure, especially in the silicified sponges, is so admirably preserved as to render this not difficult; but until their true affinities to recent species have been studied from a *strictly zoological* point of view, our knowledge concerning them must be wanting in scientific precision. The result of such inquiries will probably be to reduce many genera to the lower grade of species, and many species to mere varieties or conditions of growth. In common with other forms equally low in the scale of organization, the sponges appear to have endured through a long range of time, subject only to modifications, which scarcely amount to specific distinctions.

IV.—Further Remarks on Mr. James Geikie's Correlation of Glacial Deposits.

By S. V. Wood, Jun.

In a republication of the papers by him which appeared in successive numbers of this Magazine, Mr. James Geikie has replied to the objections which I offered to his views, and also to the views of sequence which I myself advance, by asserting that the seaward ends of glaciers never float; and that my view that "wherever the ice-sheet rested there no deposit occurred, the material produced by its action incessantly travelling outwards to the ice-edge," is a misconception.

The question whether this flotation does or does not occur is one of the things yet to be solved, and it is difficult to imagine that the continuous Antarctic ice-wall followed without soundings for hundreds of miles by Sir James Ross does not float.[1] Perhaps in thinking that it did, I too readily adopted the view of Mr. Archibald Geikie, the Director of the Scotch Survey; but the question is one wholly beside the main issue, which is—

1st. Is unstratified clay or Till deposited under the sea?

2nd. Whence does the material of such Till come unless it be a product of land-ice shed out from the sea extremity of that ice?

3rd. How, if so shed out, can it be denied that the material is constantly travelling outwards?

4th. If so travelling outwards, how can the material shed out under the sea at the commencement of a period be synchronous with the material that was under the sheet at the close of the period.

The Scotch geologists have mostly insisted on a negative to the first of these propositions; and Mr. Croll, in arguing that the unstratified clay of the Holderness cliffs—a clay identical so far as its physical structure is concerned with the Scotch Till—was due to a

[1] In supposing that, so soon as it has a tendency to float, the glacier breaks off into bergs from the rise and fall of the tide, Mr. Geikie seems to me to have overlooked the fact that in such deep water and open sea as that in which the Antarctic ice terminates, the vertical movement of the tide is altogether insignificant. It is to the Antarctic, rather than the Arctic regions, that we must turn to find the ice conditions of our Glacial period.

vast ice-sheet that filled the North Sea, urged that the remains of Mollusca occurring in the unstratified clay or Till of Caithness were due to the ploughing out of a pre-existing sea-bed, by which such remains became incorporated in the unstratified formation produced by this ice-sheet. Now the proof that unstratified Till was deposited under the sea appears to me simple and convincing. When Sir Charles Lyell visited Holderness in 1869, in company with his nephew Mr. Leonard Lyell, and Mr. Thomas M. Hughes of the Geological Survey, they found in the midst of the unstratified chalky clay (or Till, as the Scotch would call it) of the lower part of Dimlington Cliff, a thin streak of greenish sand embedded in the clay, which, according to the description of Mr. L. Lyell sent me by Sir Charles, was "*crammed with perfect specimens of Nucula Cobboldiæ.*" Some of these, Mr. Lyell adds, had he believes the two valves adherent, and certainly an *Astarte* was found in that condition.

Now here we have an unequivocal instance of a colony of Mollusca that must have established itself on a sea-bottom formed of unstratified glacial clay, and been afterwards tranquilly covered over with similar material, just in the same way in which with stratified deposits a band of shells is covered by a succeeding stratum of sand or mud. Can it be questioned in the face of this that unstratified clay or Till has been deposited under the sea, which is my first proposition? Further, if this cannot be questioned, then why refer any of this unstratified clay or Till to a deposit on a terrestrial surface? for it is quite a rare exception to find Mollusca in any part of it, no instance of the kind being known to have occurred in all the wide expanse of this chalky clay except at Dimlington.

I have elsewhere pointed out that this wholly unstratified deposit, undistinguishable in its physical character from that Scotch Till which is held to be the terrestrial deposit of land-ice, spreads evenly over large areas of stratified sands that yield Mollusca in places; and that such clay not unfrequently passes down vertically into these sands by a few feet of sandy clay obscurely stratified. Whatever therefore be the cause of the anomaly, I do not see how it can be questioned that by some means a vast mass of material, which is admitted by all to be a product of land glaciation, has been spread out under the sea over an extensive area in a wholly unstratified condition.

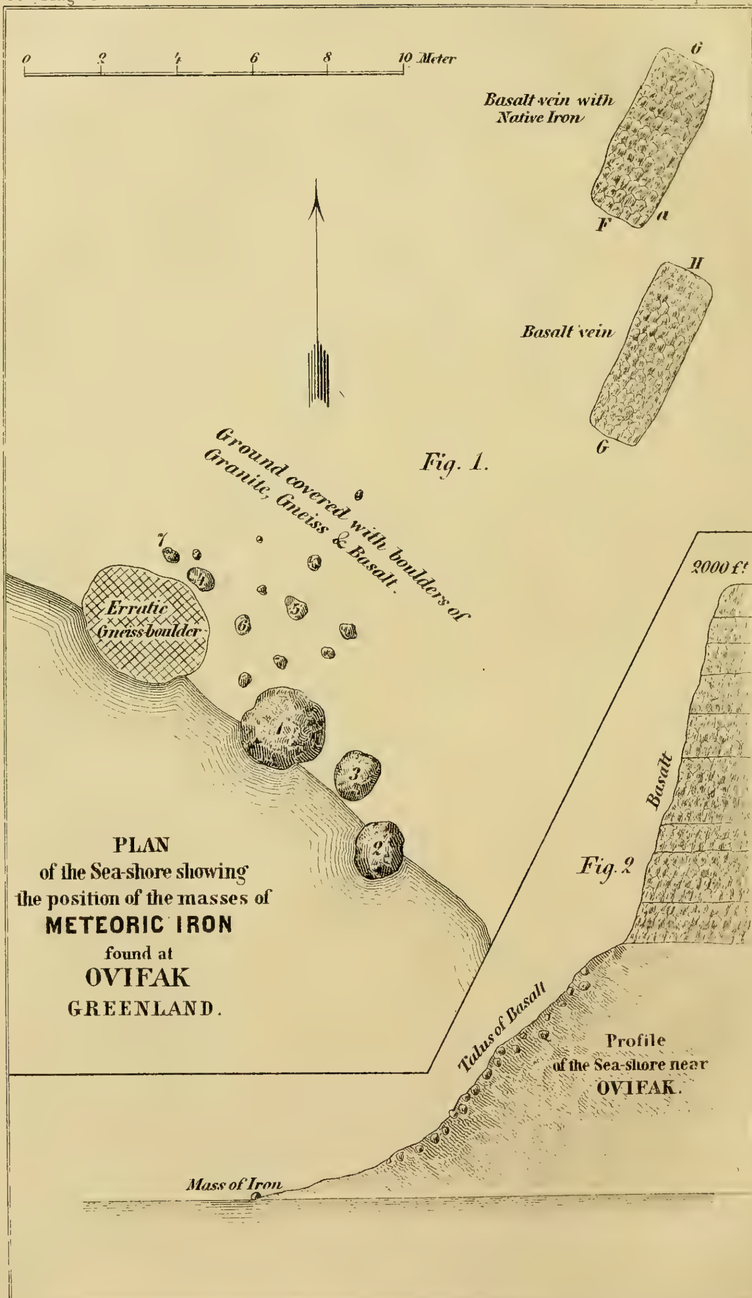
This being so, the second, third, and fourth propositions seem to me to be answered by necessary implication. It will not be denied by Mr. Geikie, or any one, that the material was generated by the action of the land-ice. It could not get out to sea in this vast volume unless its motion was incessantly outwards from beneath the generating ice-sheet; and it could not thus travel outwards without the material generated at the commencement of this action having all found its way into the sea before its termination. If, for instance, we assume the period as 100,000 years—it was probably far more—the material generated in the first 10,000 would have all found its way to the sea before the end of the second 10,000 years, and so on throughout the entire period of 100,000 years.

Mr. Geikie mentions the occurrence on the tops of the Ochils, upon the watershed of the Renfrew uplands, and on the crest of the Pentland Hills, of what he regards as true Till, containing, along with rock debris furnished by these hills themselves, material brought from the Highlands; and as this material, he considers, must have been brought by land-ice, filling the low ground between, he urges this as fatal to my views.

He has evidently misunderstood the meaning I attached to the word "deposit" in the expression I used that "where the ice rested deposit occurred." Of course, although no permanent deposit of it occurred, there was always a certain quantity of the material under the ice-sheet, or else it could not be incessantly travelling outwards to the sea: and in protected hollows the temporary accumulation of this might be considerable. Necessarily, therefore, as the sheet wasted back, there was a certain quantity of the material left on the land surface as the ice deserted it, and this would represent the Till which Mr. Geikie thus instances against me; but that material was the product of the ice-sheet just preceding its desertion of these particular spots; and was formed ages after that which occupied the same spot during the earlier part of the period, and which had all travelled out to sea long before these hills were relieved of the ice-sheet. The very circumstance instanced by Mr. Geikie of material from the Highlands finding its way to the Ochils and other isolated hills, proves that the material was thus in motion.

In a footnote to the Introduction to the Supplement of the Crag Mollusca (p. 26), this occurrence of Mollusca at Dimlington near the top of the great Chalky Clay (No. 9 of that Introduction) is noticed; but I had not seen the specimens. Since then Sir Charles Lyell has been kind enough to send them to me, and it is highly satisfactory to me to find this colony of *Nucula Cobboldiæ* occurring at an horizon in the glacial sequence so near to that at which I and my coadjutors had placed the Bridlington bed,[1] with the Mollusca of which, inclusive of this *Nucula*, these Dimlington shells agree identically, as far as they go, both in species and in mineral condition. When it is thus seen that a nest of *Nucula Cobboldiæ* lived in the British sea, after 100 feet of Glacial-clay, teeming with chalk debris similar to that forming the lower part of Dimlington Cliff, had been deposited (for to that depth is it shown by adjacent borings that this clay descends before the uniformly even chalk floor is reached), the prolonged glaciation of the Chalk wold which must have preceded the dying out of that shell will be, I think, better recognized. The existence of another 100 feet of Glacial-clay overlying this *Nucula* seam in actual section shows that a prolonged period of glaciation also succeeded it; and when it is observed that in this overlying 100 feet, the Chalk debris begins to diminish immediately above the shell seam, and

[1] Besides the observations as to the position of the Bridlington bed in the Crag Supplement Introduction, and in various papers of mine in this Magazine, the respective horizons of the Bridlington bed and of Dimlington Cliff base will be found marked in my vertical section of the Glacial sequence of the East side of England, at page 90 of vol. xxvi. of the Quarterly Journal of the Geological Society.



PLAN
of the Sea-shore showing
the position of the masses of
METEORIC IRON
found at
OVIFAK
GREENLAND.

Profile
of the Sea-shore near
OVIFAK.

entirely to disappear in the upper part, the occupation of the districts to the north by the ice-sheet after it had deserted the Chalk, and the connexion of that event with the non-occurrence of *Nucula Cobboldiæ* in Scotch and other Glacial beds, which I assign to a stage in the retreat of the ice-sheet posterior to the desertion of the Chalk, will, I think, be better understood. Nevertheless, according to my view, neither the 100 feet below nor the 100 feet above represent the whole glacial sequence, there being glacial beds anterior to the one and posterior to the other.

I would take this opportunity of adding that the Brick Clays with Mollusca of Scotland, which I thought might, from their resting on the Till, be of Post-glacial age, seem to me on further consideration to belong to the Glacial period, though to the later part of it; and I would ask Mr. Geikie if not merely the Scotch Till, but the clay he distinguishes from it and calls Boulder-clay, and the intercalated and subjacent silt, clay, and gravel, be the equivalents, as he contends, of the East Anglian and Holderness deposits, how it happens that not one of the several shells unknown as living, or as living nearer than the Pacific, which these East Anglian and Holderness Beds yield, has occurred in the many Scotch deposits which yield Mollusca thus grouped by him as equivalents of the East Anglian and Holderness beds—a part of the question which he has avoided encountering altogether.

V.—Account of an Expedition to Greenland in the year 1870.

By Prof. A. E. Nordenskiöld.

Foreign Correspondent Geol. Soc. Lond., etc., etc., etc.

Part II.

(PLATE VIII.)

(*Continued from page* 306.)

THESE holes in the ice filled with water are in no way connected with each other, and at the bottom of them we found everywhere, not only near the border, but in the most distant parts of the inland ice visited by us, a layer, some few millimetres thick, of grey powder, often conglomerated into small round balls of loose consistency. Under the microscope, the principal substance of this remarkable powder appeared to consist of white angular transparent grains. We could also observe remains of vegetable fragments; yellow, imperfectly translucent particles, with, as it appeared, evident surfaces of cleavage (felspar?); green crystals (augite) and black opaque grains, which were attracted by the magnet. The quantity of these foreign components is, however, so inconsiderable, that the whole mass may be looked upon as one homogeneous substance. An analysis by Mr. G. Lindström of this fine glacial sand gave—

Silicic acid	62·25
Alumina	14·93
Sesquioxyd of Iron	0·74
Protoxyd of Iron	4·64
Protoxyd of Manganese	0·07
Lime	5·09

Magnesia	3·00
Potassa	2·02
Soda	4·01
Phosphoric acid	0·11
Chlorine	0·06
Water, organic substance (100° to red heat)	2·86
Hygroscopic water (15° to 100°)	0·34
	100·12

After long digestion with sulphuric acid only 7·73, and with muriatic acid 16·46, per cent. was dissolved. The remainder was entirely white, after heating to redness. The analysis gives the atomic relation—

$$2\,\dot{R} + \dddot{Al} + 7\,\ddot{Si} + \dot{H}$$

or the formula—

$$2\,\dot{R}\,\ddot{Si}^2 + \dddot{Al}\,\ddot{Si}^3 + \dot{H}$$

Specific gravity $= 2{\cdot}63$ (21^{C}). Hardness inconsiderable, crystallization probably monoclinic.

The substance is not a clay, but a sandy trachytic mineral, of a composition (especially as regards soda) which indicates that it does not originate in the granite-region of Greenland. Its origin appears therefore to me very enigmatical. Does it come from the basalt-region? or from the supposed volcanic tracts in the interior of Greenland? or is it of meteoric origin? The octahedrally crystallized magnetic particles do not contain any traces of nickel. As the principal ingredient corresponds to a determinate chemical formula, it would perhaps be desirable to enter it under a separate class in the register of science; and for that purpose I propose for this substance the name Kryokonite (from *κρύος* and *κόνις*).

When I persuaded our Botanist, Mr. Berggren, to accompany me in the journey over the ice, we joked with him on the singularity of a botanist making an excursion into a tract, perhaps the only one in the world that was a perfect desert as regards botany. This expectation was, however, not confirmed. Dr. Berggren's quick eye soon discovered, partly on the surface of the ice, partly in the above-mentioned powder, a brown polycellular alga, which, little as it is, together with the powder and certain other microscopic organisms by which it is accompanied, is the most dangerous enemy to the mass of ice, so many thousand feet in height and hundred miles in extent. The dark mass absorbs a far greater amount of the sun's rays of heat than the white ice, and thus produces over its whole surface deep holes which greatly promote the process of melting. The same plant has no doubt played the same part in our country, and we have to thank it, perhaps, that the deserts of ice which formerly covered the whole of northern Europe and America have now given place to shady woods and undulating corn-fields. Of course, a great deal of the grey powder is carried down in the rivers, and the blue ice at the bottom of them is not unfrequently concealed by a dark dust. How rich this mass is in organic matter is proved by the circumstance, amongst others, that the quantity of organic matter in it was sufficient to bring a large collection of the grey powder, which had been carried away to a distant part of the ice by sundry now dried up glacier-streams, into so strong a process of fermentation or putrefaction, that the mass, even at a great distance, emitted a most disagreeable smell, like that of butyric acid.

Dr. Berggren has communicated the following notice[1] of the microscopic organisms met with on the inland ice.

"One of the species of algæ met with on the inland ice occurred in such vast quantities, that the surface of the ice throughout larger or smaller tracts was tinted with a peculiar colour. Two others seemed exclusively to belong to the fine sand, which is found either in the form of a thin covering on the surface of the ice, or as a more or less thick layer at the bottom of the pipe-like holes that appear in the surface. The first-mentioned species, occurring copiously, does not require any such substratum, but is found principally on the sides of ice-hills, where the water from the melting ice filtered itself out between the little inequalities of the surface.

"The most copiously represented species has the form of a short thread, not spreading out in branches, but consisting of a single row of cells; the number of cells in each thread is 2, 4, 8, or at most 16. Threads of 4 and 8 cells are most common. The species very frequently appears only as a single cell. The threads are usually a little bent, sometimes, when the number of cells is 16, forming a complete semicircle. The number two or its multiples taken as the standard for the number of cells in the separate threads is accounted for by the regular continuous bisection of the cells, whereby their propagation proceeds. The connexion between the cells is the looser the older the partitions become, as the older membranes assume a looser consistence. In a thread of 16 cells, the connexion between the eighth and ninth cells is soon broken, and in the two threads thus resulting the connexion between the fourth and fifth cells is weaker than that between the second and third or the sixth and seventh. The threads therefore often lie bent at an angle. The diameter of the cells is 0·008 — 0·012 mm., and their length 0·016 — 0·040 mm. Individual cells may sometimes attain a length 0·065 mm. and a breadth of 0·015 mm., whereas a great number of other single cells are met with of very small dimensions, from spherical forms of only 0·006 mm. diameter to those of ordinary form and size. As the ends of the cells, where they are joined together, are rounded, there is, of course, a contraction between them, which becomes more and more conspicuous as the connexion between them is loosened by time. The membrane is thin and hyaline, and its outermost layer (the remnants of the membranes of the mother-cells altered after division) is of an almost slimy consistence, whereby the cells are for some time kept together. The contents of the cells are in part concealed by a dark purple-brown colouring-matter, which in dried cells is immediately drawn out on wetting them. The centre of the cells is occupied by an oblong or cylindrical mass of chlorophyll, of somewhat irregular

[1] A more detailed account, accompanied by drawings, of these remarkable Algæ will hereafter be published in the "K. Vet. Akademiens Öfversigt."

contour, in the extremity of which two kernel-formed rounded bodies are imbedded, which in general cannot be perceived by the eye till the colouring-matter has been removed by means of reagents. We sometimes meet with four such bodies in one cell, sometimes but a single one: the former a result of accidentally checked division of the cells; the latter of such division having lately taken place. In the liquid of the cells a number of small grains are found, which are for the most part collected round the periphery of the cell or at its ends.

"Judging from the construction of the cells, and the manner of their multiplication, the alga before us would appear to belong to the *Conjugatæ;* but as I have not succeeded in discovering fructification in it, it would be rash to decide to which genus it is to be referred. The thread-like rows of connected cells agree with the *Zygnemaceæ;* whereas, on the other hand, an unmistakable similitude to the *Desmidiaceæ*, especially *Cylindrocystis*, and the nearly related genera, is indicated by the strongly-marked divisions into multiples of two, and by the tendency of the rows of cells to fall asunder, as far as the destructibility of the uniting cell-membranes permits, into parts consisting of cells united in pairs, which however is seldom possible, in consequence of the greater energy possessed by the power of multiplying the cells. As the above-mentioned small single cells, which occur in great numbers, are much less in diameter than those cells which arise from the bisection of the threads, they have perhaps a different origin from these latter, although the researches which I have hitherto been enabled to devote to this subject have not furnished any illustration of it. Were these daughter-cells arising from the division of the sporæ, if the above-mentioned supposition with respect to the systematic place of the species be correct, the stadium of copulation or sporæ, in some period of its development, ought to be found. Two rare forms of peculiarly constructed cells perhaps ought not to be passed over in silence. I have sometimes found the extreme cell in a thread considerably more swelled than the others, more elliptic in form, also provided with a thicker membrane, and with the contents of the cell more coarse-grained. I once found one of the middle cells in a thread thus transformed, and on two occasions I have met with single cells of the same kind. I also once met with a cell of very peculiar construction. It had the usual form, but was unusually large, with a long mass of chlorophyll, as usual, in the midst, and the granular matter grouped rather towards the ends of the cell. In it were found about twenty larger or smaller spherical bodies. Four of these lay arranged at each end of the cell, and were almost entirely opaque, of a dark brown colour, and in appearance much resembled the smaller cells of *Protococcus nivalis*. The others were translucent, with sharply defined contours. As our knowledge of the nature of these bodies is confined to what is here stated, the fuller explanation of their significance must be reserved for a future investigation.

"In places similar to those in which this species occurs, and often in company with it, *Protococcus nivalis* was met with. Amidst the fine gravel upon the ice, but to a trifling amount, small green cells are found, sometimes united in little groups, sometimes isolated, which appeared to belong to *Protococcus vulgaris*. *Scytomena gracile*, on the other hand, is everywhere met with in great profusion, wherever the gravel either lies in thinly scattered grains on the surface of the ice or forms more or less thick layers. The threads lie either alone, or united in small bunches, as they join together at the lower part, and bend backwards higher up. They are pretty stiff, S-shaped, or forming a curve of several undulations, and yellowish-brown in colour. Their length is very various, their breadth generally about 0·009 mm."

At our midday rest on the 21st we had reached latitude 68° 21′ and 36′ longitude east of the place where our tent was pitched; and a height of 1400 feet above the level of the sea.

Later in the day, at our afternoon rest, the Greenlanders began to take off their shoes and examine their little thin feet—a serious indication, as we soon perceived. Isak presently informed us, in broken Danish, that he and his companion now considered it time to return. All attempts to persuade them to accompany us a little further failed; and we had therefore no other alternative than to let them return, and continue our excursion without them.

We took up our night-quarters here. The provisions were divided. The Greenlanders, considering they might perhaps not be able to find our first depôt, were allowed to take as much as was necessary to enable them to reach the tent. We took out cold provisions for five days. The remainder, together with the excellent photogen portable kitchen, which we had hitherto carried with us, were laid up in a depôt in the neighbourhood, on which a piece of tarpaulin was stretched upon sticks, that we might be able to find the place on our return; which however we did not succeed in doing, though we must have passed in its immediate vicinity.

After these preparations for a parting, Dr. Berggren and I proceeded alone further inward. The Greenlanders turned back.

At first we passed one of the before-mentioned extensive bowl-formed excavations in the ice-plain, which is here furrowed by innumerable rivers, which often obliged us to make long circuits; and when to avoid this, we endeavoured to make our way along the margin of the valleys, we came, instead, upon a tract where the ice-plain was cloven by long, deep, parallel clefts running true N.N.E.—S.S.W., quite as difficult to get over as the rivers, but far more dangerous. Our progress was accordingly but slow. At twelve o'clock on the 22nd we halted, in glorious, warm, sunny weather, to make a geographical determination. We were now at a height of 2000 feet, in latitude 68° 22′, and in a longitude of 56′ *of arc* east of the position of our tent at the fjord.

During the whole of our excursion on the ice we had seen no other animals than a couple of ravens, which on the morning of the 22nd, at the moment of our separation, flew over our heads. At first, however, there appeared in many places on the ice remnants of ptarmigans, which seemed to indicate that these fowls visit these desert tracts in by no means inconsiderable flocks. Everything else around us was lifeless. Nevertheless silence by no means reigned here. On bending down the ear to the ice, one could hear on every side a peculiar subterranean hum, proceeding from rivers flowing within the ice; and occasionally a loud single report like that of a cannon gave notice of the formation of a new glacier cleft.

After taking the observations, we proceeded over comparatively better ground. Later in the afternoon we saw, at some distance from us, a well-defined pillar of mist, which, when we approached it, appeared to rise from a bottomless abyss, into which a mighty glacier-river fell. The vast roaring water-mass had bored for itself a vertical hole, probably all the way down to the rock, situated certainly more than two thousand feet beneath, on which the glacier rested.

The following day (the 23rd) we rested in latitude 68° 22′ and 76′ of arc longitude east from the position of our starting-point at Auleitsivik.

The provisions we had taken with us were, however, now so far exhausted, that we were obliged to think of returning. We determined nevertheless first to endeavour to reach an ice-hill visible on the plain to the east, from which we hoped to obtain an extensive view; and, in order to arrive there as quickly as possible, we left the scanty remains of our provisions and our sleeping sack at the spot where we had passed the night, taking careful notice of the ice-rocks around, and thus proceeded by forced march, without encumbrances.

The ice-hill was considerably further off than we had supposed. The walk to it was richly rewarded by an uncommonly extensive view, which showed us that the inland ice continued constantly to rise towards the interior, so that the horizon towards the east, north, and south was terminated by an ice-border almost as smooth as that of the ocean. A journey further (even if one were in a condition to employ weeks for the purpose—which want of time and provisions rendered impossible to us) could therefore evidently furnish no other information concerning the nature of the ice than that which we had already obtained; and even if want of provisions had not obliged us to return, we should hardly have considered it worth while to add a few days' marches to our journey. Our turning-point was situated at a height of 2200 feet above the level of the sea, and about 83′ of longitude, or 30 miles west of the extremity of the northern arm of Auleitsivikfjord.

On departing from the spot where we had left our provisions and sleeping sack, we had, as we supposed, taken careful notice of its situation; nevertheless we were nearly obliged to abandon our search as vain—an example which shows how extremely difficult it is, without lofty signals, to find objects again on a slightly undulating surface everywhere similar, like that formed by the inland ice.

When, after anxiously searching in every direction, we at length found our resting-place, we ate our dinner with an excellent appetite, made some further reductions in our load, and then set off with all haste back to the boat, which we reached late in the evening of the 25th.

At a short distance from our turning-point, we came to a copious, deep, and broad river, flowing rapidly between its blue banks of ice, which were here not discoloured by any gravel, and which could not be crossed without a bridge. As it cut off our return, we were at first somewhat disconcerted; but we soon concluded that—as in our journey out we had not passed any stream of such large dimensions—it must at no great distance disappear under the ice. We therefore proceeded along its bank in the direction of the current, and before long a distant roar indicated that our conjecture was right. The whole immense mass of water here rushed down a perpendicular cleft into the depths below. We observed another smaller but nevertheless very remarkable waterfall the next day, while examining, after our midday rest, the neighbourhood around us with the telescope. We saw in fact a pillar of steam rising from the ice at some distance from our resting-place, and, as the spot was not far out of our way, we steered our course by it, in the hope of meeting—judging from the height of the misty pillar—a waterfall still greater than that just described. We were mistaken: only a smaller, though nevertheless tolerably copious, river rushed down from the azure-blue cliffs to a depth from which no splashes rebounded to the mouth of the fall; but there arose instead, from another smaller hole in the ice, in the immediate vicinity, an intermittent jet of water, mixed with air, which, carried hither and thither by the wind, wetted the surrounding cliffs with its spray. We had then here, in the midst of the desert of inland ice, a fountain, as far as we could judge from the descriptions, very like the geysers which in Iceland are produced by volcanic heat.

In order, if possible, to avoid the district of ice-rocks, which on our journey out had required so much patience and exertion, we had in returning chosen a more northerly route, intending to endeavour to descend from the ice-ridge higher up on the slip of ice-free land, which lies between the inland ice and Disko Bay. The ice was here, with the exception of a few ice-hillocks of a few feet high, in most places as even as a floor, but often crossed by very large and dangerous clefts, and we were so fortunate as immediately to hit upon a place where the inclination towards the land was so inconsiderable that one might have driven up it four-in-hand.

The remainder of the way along the land was harder, partly on account of the very uneven nature of the ground, and partly on account of the numerous glacier streams which we had to wade through, with the water far above our boots. At last, at a little distance from the tent, we came to a glacier stream, full of muddy water, so large that, after several failures, we were obliged to abandon the hope of finding a fordable place. We were therefore obliged to climb high up again upon the shining ice, so as to be able to find our way down again further on, after passing the river; but the descent on this occasion was far more difficult than before.

Laborious as this journey along the land was, it was nevertheless extremely interesting to me in a geological point of view. We passed in fact over ground that had but lately been abandoned by the inland ice, and the whole bore so confusing a resemblance to the woodless gneiss-districts in Sweden and Finland, that even the most sceptical persons would be obliged to admit that the same formative power had impressed its stamp on both localities. Everywhere rounded, but seldom scratched, hills of gneiss,[1] with erratic blocks in the most unstable positions of equilibrium, occur, separated by valleys with small mountain lakes and scratched rock-surfaces. On the other hand, no real moraines were discoverable. These, indeed, seem to be in general absent in Scandinavia, and are generally speaking more characteristic of small glaciers than of real inland ice.

Fig. 1, Fig. 2, and Fig. 3. Inland Ice abutting on Land.
A. Inland Ice; B. Solid Rock; C. Small Collection of Earth at the foot of the Glacier; D. Lake; E. Separate Block of Ice.

Fig. 1.

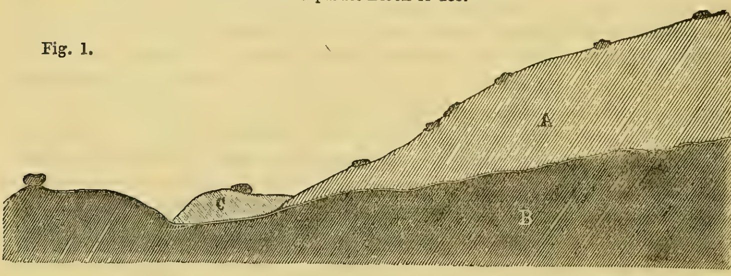


Fig. 2.

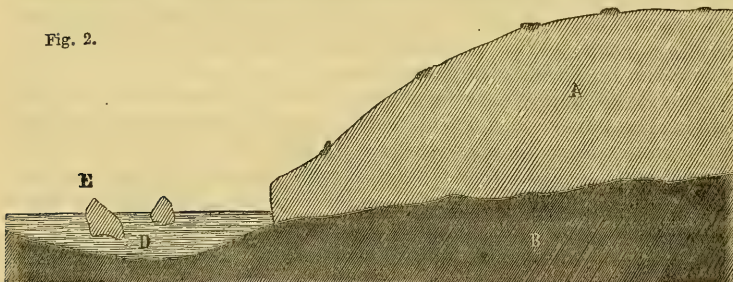


Fig. 3.

[1] For the preservation of a scratched stone surface it is necessary that it should be

The border of the ice is, as indicated in the woodcuts, everywhere sprinkled with smaller boulders, partly rounded, partly angular ; but the number of these is so inconsiderable, that, when the ice retires, they only give rise to a slope covered with boulders, not to a moraine, similar, for example, to that which the little Assakak glacier in Omenakfjord drives before it. The little earth-bank, which at most places collects at the foot of the glacier, is frequently washed away again by the glacier streams and rain. We often find at the foot of the glacier, as indicated in Fig. 2, ponds or lakes in which a fresh-water glacial clay, containing angular stone blocks, scattered around by small icebergs, is deposited.

It is a common error among geologists to consider the Swiss glaciers as representing on a small scale the inland ice of Greenland, or the inland ice which once covered Scandinavia.[1] The real glacier bears the same relation to inland ice which a rapid river or brook does to an extensive and calm lake. While the glacier is in perpetual motion, the frozen water of the inland ice, like the water of a lake, is comparatively at rest, excepting in those places where it streams out into the sea by vast but short glaciers. If one of these glaciers, through which the ice-lake falls out into the sea, pass over smooth ground where the ocean's bottom gradually changes into land without any steep breaks, steep precipitous glaciers are produced, from which

FIG. 4.

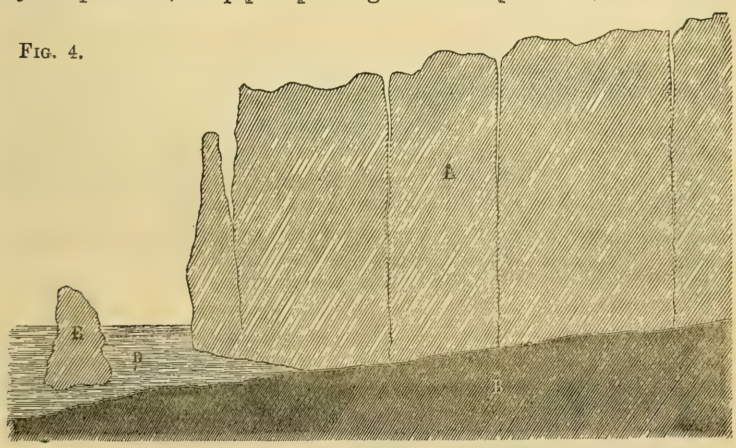


Fig. 4. Inland ice extending into the sea and terminating in a steep edge, 100 to 200 feet high.

indeed large ice-masses fall down, but do not give rise to any real iceberg. But if the mouth be narrow, the depth of the outlying sea great, and the inclination of the shore considerable, the result will

protected by a layer of water, clay, or sand, from the destructive effects of frost, and more especially from those of lichens. The finest scratches disappear in a few years from a mountain slab, the position of which is favourable to lichen vegetation, but are on the contrary preserved where lichen vegetation cannot develope itself—as for example, when the rock is for a time in the spring covered with water.

[1] Switzerland was probably never quite covered with real inland ice, its glaciers have only been considerably more extensive than they now are.

be one of those magnificent ice-fjords which Rink so admirably describes, and which we, later in the course of our journey, had an opportunity of visiting. The following diagram will illustrate this more clearly.

FIG. 5.

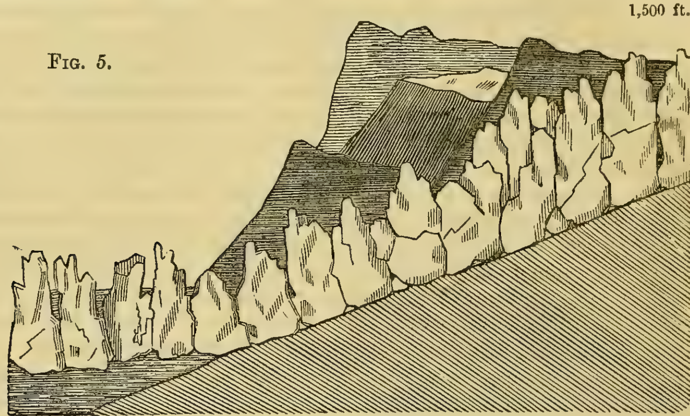


Fig. 5. Inland ice abutting on the bottom of an ice-fjord, *i.e.* a fjord in which real icebergs are formed.

True icebergs are formed only in those glaciers which terminate in the manner indicated in Fig 5; though pieces of ice of considerable dimensions may fall from a steep precipice (Fig. 4). These various kinds of glaciers occur not only in Greenland, but also in other ice-covered polar lands, *e.g.* in Spitzbergen, though on so much smaller a scale than in Greenland, that one never meets in the surrounding waters with icebergs at all comparable in magnitude with those of Davis Strait.

In Spitzbergen, and probably also in some parts of Greenland, the ice passes into the sea in the following manner.

FIG. 6.

Fig. 6. Inland ice abutting on a mud-bank.

As I have already remarked in the account of the geological relations of Spitzbergen, this last-mentioned kind of termination of inland ice towards the sea is met with only either in those places where the limits of the inland ice rapidly recede, or where the ice breaks for itself a new channel or way to the sea. This is, for example, the case with Axels glacier in Bell Sound, which, when I first visited the spot in 1858, had an edge like that indicated in

Fig. 6, but which a couple of years later filled the whole of the harbour lying before it, and is now terminated in the manner shown in Fig. 5.

The great denuding effect of the glaciers has been, as is known, proved by numerous and accurate investigations. Greenland also offers examples of this in the long and deep fjords that indent its coasts, and which, if they run parallel to ante-glacial depressions of the earth's crust, yet, as the smoothed, scratched and grooved rocks and the erratic blocks strewn high up upon the slopes show, have been widened, formed, and cleansed from earth, gravel-beds, and looser sedimentary mountain detritus by the operation of the glaciers. The mere effect of the immovable inland ice cannot be any thing like so great. Nevertheless, here also the earth and the layers of gravel are completely washed away by the rapid glacier streams running under the ice. The subjacent original rock is thus exposed, and perhaps to some extent worn away, especially in places where the ice passes over layers of limestone, sandstone, or slate. Its original depressions, filled during the older geological periods, therefore re-appear, and often form—when the ice covering has again retired—the basins of those beautiful lakes which characterize all glacial lands. To assume that the whole lake-basin has been scooped out during the glacial period is, however, evidently a mistake; and equally erroneous is the form in which it is customary to clothe the theory of the origin of Alpine lakes. But when we take into consideration how rapidly (even within historical periods) a lake is filled and converted—first into a morass, and then to a level and dry plain—we easily see the reasonableness of the following proposition:

We meet with lakes only in those places where, from some cause or other, during the latest geological periods, depressions or excavations have taken place in the crust of the earth; and since, among more generally operating causes than this, we know only of the volcanic and glacial powers, it is natural to conclude that modern (not filled up) lake-basins only occur where the strata, in consequence of volcanic activity, have fallen in, or where the ice has ground to powder, and the glacier-streams have swept away, the looser earth and rocks situated nearest to the surface of the earth.

On observing Tessiursarsoak from the heights nearest to the spot where we had first descended from the glacier, we had perceived that its appearance had changed in a remarkable manner; its surface was bright as a looking-glass, and so thickly covered with ice that our first impression was that we had an arm of the inland ice before us. On arriving at the tent we discovered the cause of this. During our absence the inland ice had launched or deposited ice in such quantities that the whole bay was almost choked with it, and the Greenlanders were very uneasy, for fear partly of our being inclosed, and partly of the violent waves caused by the deposition. They were therefore very glad when, immediately on our arrival at the boat, we declared our readiness to start on the following day.

In order to be in time to meet the Inspector—who just at this time was expected to visit the colonies around Disko Bay in a commodious yacht, whence he was to sail through the Waigat up to Upernivik, and who had offered us a place on board as far as our routes were the same—we had agreed with several Kayak men from Ikamiut and the surrounding districts, that they on an appointed day were to meet at the place of our tent at Tessiursarsoak. Our intention was to have the whale-boat dragged over the low neck of land which at Sarpiursak separates the innermost part of the north arm of Auleitsiviksfjord from Disko Bay, and thus entirely to avoid the long circuit round Kangaitsiak. At the apppointed time we saw a whole flotilla of these small, elegant, and light vessels approaching our tent. We immediately started, and, as soon as the necessary dram of welcome had been distributed to the canoe-men, rowed over to the other side, where Dr. Öberg, with the crew of the zoological boat and a number of other men, awaited us. We were now a numerous body of men, but Greenlanders are neither strong men nor inclined to unusual exertions. We were accordingly obliged to let our people row the whale-boat all the way round, while we ourselves, with our effects, passed directly over to Sarpiursak, where two other whale-boats lay at our disposal.

According to Dr. Rink, the interior of the fjord we had just left had never before been visited by Europeans, and even natives only visit it in summer to hunt and fish, usually in an "umiak," which is carried over the neck of land. It is seldom that they row from the mouth to the end of the fjord. They are afraid of the violent currents which the tide water produces in the long narrow estuary, and which, as the Greenlanders several times, with horror painted on their countenances, informed us, when we wished to take advantage of the favourable but violent current to get on faster, had once swallowed up two "umiaks," with all the men, women, and children on board. There must now, however, be but very little to be got by hunting there; at least, during the whole of our journey we saw no reindeer. But there are persons still living who remember the time when thousands of reindeer were killed in these parts for the sake of the skins only. This abundance of game enticed a few families to settle there also during winter, and one meets in several places traces of old houses. The shores of the fjord are occupied by gneiss hills separated from each other by valleys, in which grass and lichen grow plentifully, thus affording copious pasture for such reindeer as may occasionally stray thither. This is an event which has now become rare, but many maintain that the good times may return, for that, according to their account, the reindeer make periodical migrations, sometimes appearing at a particular place in vast numbers, and then suddenly disappearing, and there are many persons who connect this account with that of an inland tract free from ice, or even with the story of wild inhabitants with European features in the interior of the country. To us the visit to this fjord was interesting, partly because we hoped thus to become acquainted with the true, unmixed Greenlander scarcely in contact with civilization, and partly for botanical reasons. We hoped in fact here, far from the moist fogs of the ocean, to find a far richer vegetation than on the outer coast. A very small tree was said to have been thence transplanted to the clergyman's garden at Egedesminde. This anticipation of the botanist was however not confirmed, at least not to the amount expected. The flora was indeed richer and the willow-bush larger than at Egedesminde, but not so rich nor so large as in the more northerly situated but fertile basalt-region of Disko, which is travelled by subterranean streams of warm water. The insect Fauna, on the other hand, appears to be somewhat richer here than on the coast; at least we collected the best harvest of insects that we had during the whole summer on the 17th of July, on a little island in Tessiursarsoak, and the time we spent at the foot of the inland ice was, although in other respects extremely pleasant, embittered to a degree—of which those who have not experienced it cannot form an idea—by countless swarms of gnats. The Greenland gnat is like ours, but its bite is far more venomous, though at first not particularly painful. One is therefore usually too incautious at first, and exposes oneself to twenty or thirty gnat-bites in the face at once. A few hours later one's face becomes unrecognizable with the boils and swellings caused by the bites, and this is followed by pain and fever, especially at night, which hinders sleep, and is almost enough to drive one mad.

The inland ice, in former times, evidently covered the whole of Auleitsiviksfjord, together with the surrounding valleys, mountains, and hills. The ice has accordingly, during the last thousand or hundred thousand years, considerably retired. Now, on the contrary, its limit in these parts is advancing, and that by no means slowly. Of late years the rowing of an "umiak" in Tessiursarsoak has been rendered difficult by ice-blocks fallen from the glaciers, which is said not to have been the case formerly; and one of our rowers, Henry Sissarniak, even affirms that he, seven years ago, without obstruction rowed round an island, which now forms a peninsula jutting out from the margin of the inland ice. Many similar examples in North Greenland are adduced: thus, for example, the glacier that issues into Bläsedal, near Godhavn, has, since the time when Dr. Rink mapped that place, according to the statement of Inspector Smith, advanced much farther into the valley,—in the fjords around Omenak the ice has advanced considerably within the memory of man,—a path formerly often frequented between Sarfarfik and Sakkak is now closed by inland ice, etc., etc. I shall have occasion hereafter to mention a similar case in the ice-fjord at Jakobshavn. In a word, there can be no doubt that in many parts of North Greenland the inland ice is certainly gaining ground; but I nevertheless think that the conclusion drawn by many persons, that the whole coast of North Greenland will, at no very distant period, be again covered with ice, is somewhat too hastily made. These persons, in observing the phenomena relative to this subject, not only seem to have forgotten to register the examples occasionally adduced by the Greenlanders of a retiring of the ice—a less striking and therefore less observed phenomenon,—but they have also attributed far too great weight to an experience extending only over a few years, which may perhaps have been peculiarly unfavourable. On the contrary, the extensive, rounded, polished, and grooved border of land, which almost everywhere separates the inland ice from the extreme coast, shows plainly that the inland ice has in many places during the last geological period retired several miles. That this border-land has been uncovered later even than that at Spitzbergen is evidenced, by this fact, among others, viz. that not one of the numberless small sea-basins in North Greenland, in spite of the suitableness of the locality for moss-vegetation, has yet become filled with turf, even to the depth of a few feet, which indicates that the slip of ice-free land is but a child of yesterday. It is true that "turf" is the Greenlander's principal winter fuel, but what he means by that name is, in almost all instances, merely an earth consisting of rotten moss, grass-roots, and guano and refuse, which to the depth of a few inches is soon formed on the skerries and islands in the sea, and serves the sea-fowls as places of incubation. The greatest part of the Greenlander's turf-beds are situated on gulls' hillocks ("maagetuer"), and have, therefore, geologically speaking, nothing in common with what we mean by turf layers. It was accordingly impossible for me to collect, as I had desired, by an examination of the older turf-beds, materials for determining the latest Post-tertiary changes of climate that have taken place in Greenland. But instead, we, find here many other deposits, which serve at least to give an indication of the changes that the animal world has undergone during the Glacial period.

(*To be continued in our next.*)

NOTICES OF MEMOIRS.

THE FOSSIL MAN OF MENTONE.[1]

Abstracted from the *Comptes Rendus*, No. 26, p. 1597, June 24, 1872.

A SECOND communication on this subject has been presented by M. E. Rivière to the Academy of Sciences, containing an account of the measurements of different parts of the skeleton, and of the assoicated fossil fauna found in the Baoussé-roussé cavern, and of which a notice appeared in this MAGAZINE for June. The skeleton is of large size and nearly complete; some of the bones of the feet are wanting, as also the lower extremity of the left tibia, and the posterior extremity of the calcaneum of the same side, which were broken during the excavation. From the fractured state of the skull it was scarcely possible to take the exact dimensions; it was elongate, very dolicocephalous, less large than the skull No. 1 (*crâne de vieillard*), found at Cro-Magnon in 1868, with which it offers the greatest analogy, and specially with the orbit, which presents, as in that skull, a very extended transverse diameter, and a very reduced vertical one; the superior orbital margin is thin and sharp, less so, however, than that of the skull No. 1 of Cro-Magnon, and the inferior margin is also less thick than in the latter.

[1] See the GEOLOGICAL MAGAZINE for June last, p. 272. *With an engraving.*

The different species of animals found near the skeleton, in the determination of which M. Rivière has been assisted by Dr. Sénéchal, are—CARNIVORES.—*Felis spelæa, Ursus spelæus, Ursus,* probably *U. arctos, Canis lupus, Erinaceus.* PACHYDERMS.—*Rhinoceros, Equus, Sus scrofa.* RUMINANTS.—*Bos primigenius, Cervus alces, C. Canadensis,* a *Cervus* smaller than *C. elaphus,* and which may be that of Corsica, *C. capreolus, Capra primigenia ?* (Gervais), *Antilope rupicapra,* or Chamois. RODENTS.—*Lepus,* a lower jaw with teeth. Among the animals above enumerated, three by their presence around the skeleton and above it—the great *Felis, Ursus spelæus,* and *Rhinoceros,* and which had been found previous to the human skeleton—indicate, M. Rivière thinks, the epoch at which the fossil man of Baoussé-roussé had lived. The Reindeer has not been found in the caves of Mentone, and its remains appear to be equally wanting in the other caverns of Italy. Among the principal objects found near the skeleton were two flint knives, a bone pin worked from the radius of a stag, shells (*Nassa neritea*), twenty-two perforated canines of the Stag, all these objects having the red colour of the other parts of the skeleton and chiefly of the head. This colour is due to peroxide of iron, formed by the hydration of oligist iron, of which the surface of the body had been covered after death, showing the interment of the fossil man. This interment had taken place without any disturbance, on a soil formed of cinders, charcoal, and calcined stones, and among the remains of the life of the period.[1]

J. M.

REVIEWS.

REVIEW OF THE CONTRIBUTIONS TO FOSSIL BOTANY PUBLISHED IN BRITAIN IN 1871.

By WILLIAM CARRUTHERS, F.R.S.

THE following papers have been published :—

BAILY, W. H. Figures of Characteristic British Fossils. Part iii. pl. 28.

The author devotes this plate to representations of four plants from the Devonian measures of Ireland and Scotland, namely, *Palæopteris hibernica*, Schimp.; *Knorria Bailyana*, Schimp.; *Cyclostigma Kiltorkense*, Haught.; and *Leipdodendron nothum*, Ung.

BINNEY, E. W. Observations on the Structure of Fossil Plants found in the Carboniferous Strata. Part ii. *Lepidostrobus* and some allied cones. Palæont. Soc., Mon., pp. 33–62, pl. vii.–xii.

The author figures two cones, which, from the similarity in the structure of their axis respectively to *Lepidodendron Harcourtii*, With., and *L. vasculare*, Binney, he believes to be the fruits of these species. Nine cones, belonging to the same group as that to which the name *Flemingites* was given, are figured, and named as eight new species of *Lepidostrobus.* The most important observation in regard to these cones is the discovery, according to the author, of microspores in the sporangia of the upper portion of one of the cones, and the existence in all of them of sporangia inclosing the macrospores (Binney) or sporangia (Carruthers). (See further on, under EQUISETACEÆ, *Lepidostrobus ambiguus.*) Under the name *Bowmanites Cambrensis* (gen. and sp. nov.), Mr. Binney figures a Calamitean cone, in which several sporangia are borne in a linear series on each scale. It is to be regretted that the author gives

[1] For a further account of this interesting discovery, see the article by Professor Morris in the July number of the *Popular Science Review.*

no diagnostic characters for the new genus and the many new species he proposes in this important memoir.

Carruthers, W. On some supposed Vegetable Fossils. Quart. Journ. Geol. Soc., vol. xxvii. pp. 443–448, pl. xix.

The author describes some physical impressions and zoological structures, which have been erroneously supposed to belong to the vegetable kingdom.

——— On two Undescribed Coniferous Fruits from the Secondary Rocks of Britain. Geol. Mag., Vol. VIII. pp. 540–544, Pl. XV.

The author describes the cone of a second species of Pine associated with a second species of *Sequoia* from the Gault, and shows that the type of Pine associated with the Wellingtonias of the Gault was the same as that now found with these trees in Western North America.

——— On the History and Affinities of the British *Coniferæ*. Abstract. Brit. Ass. Reports, 40th Meeting, p. 71.

The author traces the appearance, development, and affinities of the fossil and recent Conifers of Britain.

——— On the Sporangia of Ferns from the Coal Measures. Abstract. Brit. Ass. Reports, 40th Meeting, p. 71.

The sporangia are referred to Hymenophyllaceous Ferns.

——— Remarks on the Fossils from the Railway Section at Huyton. Abstract. Brit. Ass. Reports, 40th Meeting, p. 71.

The author described in general terms a series of Carboniferous fossils collected at Huyton by the Rev. H. Higgins.

———Note on an Antholithes discovered by C. W. Peach, Esq. Abstract. Brit. Ass. Reports, 40th Meeting, p. 72.

The specimens showed that *Antholithes* were the spikes of *Cardiocarpon.*

Dawson, J. W. On Spore-cases in Coals. (Reprinted from 'Silliman's Journal,' April, 1871.) Ann. Mag. Nat. Hist. 1871, pp. 321–329.

The author figures some spore-cases from a brown bituminous shale of Upper Devonian age from Kettle Point, Lake Huron, which he names *Sporangites Huronensis* and he considers they belong to the species of *Lepidodendron* found in the bed. His *Sporangites glabra* is "almost without doubt the spore-cases of *L. corrugatum.*" He has found spore-cases in many American coals, but he considers their presence as "accidental rather than essential to coal-formation."

——— The Fossil Plants of the Devonian and Upper Silurian Formations of Canada. Montreal and London, 1871, p. 100, pl. i.–xx.

The author gives the results of his researches in these strata prosecuted for several years, and here brought to a conclusion, so far as the accessible material will admit. He reports more than 120 species of land plants. The work is, with a few additions and some necessary changes, the same as the memoir read to the Royal Society in 1870, and now in its archives. Twenty-six new species are named, mostly founded on very imperfect materials, and imperfectly described. These new species are included in the systematic list.

——— On New Tree-ferns and other Fossils from the Devonian. Quart. Journ. Geol. Soc. vol. xxvii. pp. 269-275, pl. xii. Abstract. Geol. Mag., Vol. VIII. p. 231.

Three Fern stems and some other fossils are described in this paper from the Devonian rocks of North America.

——— On the Structure and Affinities of *Sigillaria*, *Calamites*, and *Calamodendron*. Quart. Journ. Geol. Soc. vol. xxvii. pp. 147–161, pl. vii.–x.

The author holds that *Calamites* and *Lepidodendron* are distinctly cryptogamous, and are related to, or included in *Equisetaceæ* and *Lycopodiaceæ;* but *Calamodendron* seems to form a connecting link between *Calamites* and the ribbed *Sigillariæ,* while *Lepidophloios* seems to connect *Lepidodendra* with *Sigillariæ* of the *Favularia* type. On the other hand, the ribbed *Sigillariæ* may be related through *Dadoxylon* to the modern Conifers, and the *Favulariæ* may be related to the Cycads.

Heer, Oswald. On the Carboniferous Flora of Bear Island. Abstract. Quart. Journ. Geol. Soc. vol. xxvii. p. 1; Ann. Mag. Nat. Hist. vol. vii. p. 175.

The author compares the flora of this island with the plants found in the Yellow Sandstones of Ireland, and concludes that they are of Lower Carboniferous age, and form a special group, for which he proposes the name "Ursa-stage."

Hull, Edward. On the Geological Age of the Ballycastle Coalfield, with Palæontological Notes by W. H. Baily. Journ. Roy. Geol. Soc. Ireland, vol. ii.

The author considers these beds the equivalents of the Upper beds of coal under the Lower Carboniferous series of Scotland. The report by Mr. Baily on the fossils confirms this opinion. The only fossils found belong to known species of the genera *Sigillaria* and *Lepidodendron.*

PHILLIPS, JOHN. Geology of Oxford and the Valley of the Thames. Oxford, 1871, pp. 523.

This volume contains lists, and sometimes descriptions and figures, of the plant-remains found in the different formations within the boundaries to which it refers. The new species are included in the systematic list.

THOMSON, J. On the Occurrence of *Stigmaria stellata*, Eichw., in the Lower Carboniferous rocks, Lanarkshire. Abstract. GEOL. MAG. Vol. VIII. p. 236.

WILLIAMSON, W. C. On the Organization of *Volkmannia Dawsoni.* Mem. Lit. Phil. Soc. Manch., 3rd series, vol. v. pp. 28–40, pl. i.–iii. Abstract. Proc. Lit. Phil. Soc. Manch. vol. x. pp. 105, 106.

The author describes the minute structure of a Calamitean cone of the same type as that to which Binney had given the name *Bowmanites Cambrensis.* Each whorl of leaves in the cone supports several sporangia in a linear series.

——— On *Stigmaria.* Abstract. Proc. Lit. Phil. Soc. Manch. vol. x. pp. 116–118.

The author describes this fossil as having a true cellular pith and two kinds of medullary rays. It could not be the root of *Lepidodendron,* and it showed that we were still ignorant of the internal organization of *Sigillaria.*

——— On the Organization of the Stems of Calamites. Abstract. Brit. Ass. Reports, 40th Meeting, pp. 89, 90. Abstract. Proc. Roy. Soc. vol. xix. pp. 268–271. Ann. Mag. Nat. Hist. pp. 299–302.

The author describes the minute structure of the stems, which he places in two generic groups, the *Calamites* and *Calamopitus,* the former to comprehend those without infranodal canals, the latter those which possess them.

——— On the Organization of the Fossil Plants of the Coal Measures. Part ii., *Lepidodendra* and *Sigillariæ.* Abstract. Proc. Roy. Soc. vol. xix. pp. 500–504. Ann. Mag. Nat. Hist. pp. 134–138.

The author describes the structure of *Lepidodendron, Sigillaria, Diploxylon, Ulodendron, Halonia,* and *Favularia,* and believes that all these forms are but modifications of the Lepidodendroid type.

YOUNG, J., and JAS. ARMSTRONG. On the Carboniferous Fossils of the West of Scotland. Trans. Geol. Soc. Glasgow, vol. iii., Suppl.

The authors give a systematically-arranged list of the known fossil plants, amounting in all to ninety species, with the localities where they have been found.

Synopsis of the Genera and Species Described or Figured in the Memoirs enumerated above.

FILICES.

Caulopteris Lockwoodi, Dawson, Quart. Journ. Geol. Soc., vol. xxvii. p. 270; pl. xii. f. 1–3. *Devonian.* Gilboa.

C. antiqua, Newb.; Daws. Quart. Journ. Geol. Soc. vol. xxvii. p. 271; pl. xii. f. 4. *Devonian.* Ohio.

C. peregrina, Newb. l. c. p. 272; pl. xii. f. 506. *Devonian.* Ohio.

Glossopteris longifolius, Phillips, Geol. Oxford, p. 168. *Oolite.* Eyeford.

Neuropteris retorquata, Daws. Foss. Pl. Canada, p. 50; pl. xvii. f. 197. *Devonian.* Lepreau.

N. Selwyni, Daws. l. c.; pl. xvii. f. 198. *Devonian.* St. John.

Palæopteris hibernica, Schimp.; Baily, Characteristic British Foss. pl. 28, f. 1.

Pecopteris approximata, Phillips, Geol. Oxford, p. 168; diag. xxviii. f. 2. *Oolite.* Stonesfield.

P. densifolia, Daws. Foss, Pl. Canada, p. 56; pl. xvii. f. 195, 196. *Devonian.* St. John.

P. diversa, Phillips, l. c.; diag. xxviii. f. 1. *Oolite.* Stonesfield.

P. incisa, Phillips, l. c.; diag. xxviii. f. 5. *Oolite.* Stonesfield.

Psaronius Erianus, Daws. Foss. Pl. Canada, p 58. *Devonian.* New York.

P. textilis, Daws. l. c. p. 59. *Devonian.* New York.

Rachiopteris gigantea, Daws. Foss. Pl. Canada, p. 57. *Devonian.* New York.

R. palmata, Daws. l. c. *Devonian.* New York.

Sphenopteris plumosa, Phillips, Geol. Oxford, p. 168; diag. xxviii. f. 3. *Oolite.* Stonesfield.

S. splendens, Daws. Foss. Pl. Canada, p. 53; pl. xvi. f. 186. No locality.

Tæniopteris angustata, Phillips, Geol. Oxford, p. 168; diag. xxviii. f. 8–10 *Oolite.* Stonesfield.

EQUISETACEÆ.

Annularia laxa, Daws. Foss. Pl. Canada, p. 31; pl. vi. f. 64–69. *Devonian.* Gaspe.

Asterophyllites lenta, Daws. Foss. Pl. Canada, p. 29; pl. v. f. 60. *Devonian.* St. John.

Bowmanites Cambrensis, Binney, Carb. Fl. p. 59; pl. xii. Pal. Soc. *Carboniferous.* Pontypool, S. Wales.

Calamites, Williamson, Brit. Ass. Rep. 40th Meeting, p. 89; Proc. Roy. Soc. vol. xix. p. 268.

Calamodendron antiquius, Daws. Foss. Pl. Canada, p. 24; pl. iii. f. 39. *Devonian.* Lepreau.

C. tenuistriatum, Daws. l. c. p. 25; pl. iii. f. 40. *Devonian.* Lepreau.

Calamopitus, Williamson, Brit. Ass. Rep. 40th Meeting, p. 90; Proc. Roy. Soc. vol. xix. p. 271.

Lepidostrobus ? ambiguus, Binney, Carb. Fl. p. 55; pl. xi. f. 1. Pal. Soc. This undoubtedly belongs to the genus *Bowmanites*, which Mr. Binney figures in his next plate. The elaborate drawings and descriptions of Professor Williamson show beyond doubt, what the analogy of allied plants made one expect, that the round bodies are sporangia, and not as Mr. Binney supposes macrospores; and the introduction of a large sac inclosing the sporangia in this species makes it doubtful whether they exist in the specimens of cones of *Flemingites*, which he figures as seven species of *Lepidostrobus*. Besides, the preparations of Professor Huxley have conclusively established my interpretation of the "macrospores," for he had detected around these bodies immense quantities of microspores composed, as in R. Brown's *Triplosporites*, of three sporules, and in the interior of some of the "macrospores" themselves he had observed and has shown to me several microspores yet remaining. *Carboniferous.* Arran.

Pinnularia elongata, Daws. Foss. Pl. Canada, p. 33; pl. vii. f. 77. *Devonian.* St. John.

P. nodosa, Daws. l. c.; pl. vii. f. 78. *Devonian.* St. John.

Sphenophyllum ovale, Phillips, Geol. Oxford, p. 86; f. 3. *Carboniferous.* Forest of Dean.

Volkmannia Dawsoni, Williamson, Mem. Lit. Phil. Soc. Manch. 3rd ser. vol. v. p. 28; pl. i.–iii. This obviously belongs to Binney's genus *Bowmanites*, and is perhaps the same species as that of which Binney figures the external form. *Carboniferous.*

LYCOPODIACEÆ.

Arthrostigma gracile, Daws. Foss. Pl. Canada, p. 41; pl. xiii. *Devonian.* Gaspe. This is a species of that group of plants to which Haughton gave the name *Cyclostigma*. It has no points of correspondence with *Calamites;* the leaves are spirally arranged in all the specimens figured, and not in whorls as in Dr. Dawson's restoration.

Cyclostigma densifolium, Daws. Foss. Pl. Canada, p. 43; pl. viii. f. 92–96. *Devonian.* Gaspe.

C. Kiltorkense, Haught.; Baily, Characteristic Brit. Foss. pl. 28. f. 3. *Devonian.* Kiltorkan.

Knorria Bailyana, Schimp.; Baily, Characteristic Brit. Foss. pl. 28. f. 2. *Devonian.* Kiltorkan.

Lepidodendron, Williamson, Proc. Roy. Soc. vol. xix. p. 500.

L. Harcourtii, Witham; Binney's Carb. Fl. p. 46; pl. vii. Pal. Soc. *Carboniferous.* Oldham.

L. nothum, Ung. Baily, Characteristic Brit. Foss. pl. 28, f. 4. *Devonian.* Caithness.

L. vasculare, Binney, Palæont. Soc. l. c. p. 49; pl. viii. *Carboniferous.* Oldham.

Lepidophloios antiquius. Daws. Foss. Pl. Canada, p. 36; pl. viii. f. 90, 91. *Devonian.* Gaspe.

L. dubius, Binney, l. c. p. 52; pl. ix. f. 3. *Carboniferous.* Airdrie.

L. Hibbertianus, Binney, l. c. p. 55; pl. x. f. 2. *Carboniferous.* Burdiehouse.

L. latus, Binney, l. c. p. 57; pl. xi. f. 3. *Carboniferous.* Arran.
L. levidensis, Binney, l. c. p. 54; pl. x. f. i. *Carboniferous.* Airdrie.
L. Russellianus, Binney, l. c. p. 51; pl. ix. f. 1, 2. *Carboniferous.* Airdrie.
L. tenuis, Binney, l. c. p. 53; pl. ix. f. 4. *Carboniferous.* Airdrie.
L. Wuenschianus, Binney, l. c. p. 56; pl. xi. f. 2. *Carboniferous.* Arran.
Sigillaria, Williamson, Proc. Roy. Soc. vol. xix. p. 500.
Stigmaria, Williamson in Proc. Lit. and Phil. Soc. vol. x. p. 116.
S. areolata, Daws. Foss. Pl. Canada, p. 23; pl. iii. f. 33. *Devonian.* Gaspe.
S. minutissima, Daws. l. c. p. 23; pl. iii. f. 34. *Devonian.* Gaspe.
S. perlata, Daws. l. c. p. 22; pl. iii. f. 32. *Devonian.* St. John.
S. stellata, Eichw.; Thomson, Geol. Mag. Vol. VIII. p. 236. *Carboniferous.* Lanarkshire.

Cycadeæ.

Palæozamia megaphylla, Phillips, Geol. Oxford, p. 169; diag. xxx. f. 1. *Oolite.* Stonesfield.
Pterophyllum Buckmanni, Phillips, Geol. Oxford, p. 170. *Oolite.* Sevenhampton.

Coniferæ.

Antholithes floridus, Daws. Foss. Pl. Canada, p. 63; pl. xix. f. 236. No locality.
Araucarites sphærocarpus, Carr. Geol. Mag. Vol. VIII. p. 542. *Oolite.* Bruton, Somersetshire.
Brachyphyllum solitarium, Phillips, Geol. Oxford, p. 120. *Lias.* Bidford.
Cardiocarpon ovale, Daws. Foss. Pl. Canada, p. 60; pl. xx. f. 223, 224. *Devonian.* St. John.
Carpolithes compactus, Daws. Foss. Pl. Canada, p. 63; pl. xix. f. 229. *Devonian.* St. John.
Dadoxylon Newberryi, Daws. Foss. Pl. Canada, p. 14; pl. i. f. 7–9. *Devonian.* Ohio.
Ormoxylon erianum, Daws. Foss. Pl. Canada, p. 14; pl. i. f. 10–14. *Devonian.* New York.
Pinites dejectus, Carr. Geol. Mag. Vol. VIII. p. 541. *Kimmeridge Clay.* Kimmeridge.
P. hexagonus, Carr. Geol. Mag. Vol. VIII. p. 540; Pl. XV. *Gault.* Folkestone.
Sequoiites ovalis, Carr. Geol. Mag. Vol. VIII. p. 541. *Gault.* Folkestone.
Trigonocarpum perantiquum, Daws. Foss. Pl. Canada, p. 62; pl. xix. f. 228. *Devonian.* St. John.

Incertæ sedis.

Breea eulassioides, Lloyd; Phillips, Geol. Oxford, p. 95. *Permian.* Meriden.
Carpolithes plenus, Phillips, Geol. Oxford, p. 300; pl. xiii. f. 1. 2. *Coralline Oolite.* Marcham.
Nœggerathia Gilboensis, Daws. Quart. Journ. Geol. Soc. vol. xxvii. p. 273; pl. xii. f. 8. *Devonian.* Gilboa. It is impossible to determine what this fragment is, and it is to be regretted that it has received a specific name.

Excluded.

Carpolithes permianus, Gein.; Carruthers, Quart. Journ. Geol. Soc. vol. xxvii. p. 446.
C. umbonatus, Sternb.; Carruthers, Quart. Journ. Geol. Soc. vol. xxvii. p. 446; pl. xix. f. 12–17.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—June 5, 1872.—J. Gwyn Jeffreys, Esq., F.R.S., in the Chair.—The following communications were read:—1. "Notes on Sand-pits, Mud-volcanoes, and Brine-pits, met with during the Yarkand Expedition of 1870." By George Henderson, M.D., F.L.S. Communicated by R. Etheridge, Esq., F.R.S., F.G.S.

The author described some very remarkable circular pits which occurred chiefly in the valley of the Karakash river. These pits varied in diameter from six to eight feet, and were between two and three feet deep, the distances between the pits being about the same as the diameters. He accounted for the formation of the pits by supposing that the water, which sinks into the gravel at the head of the valley, flows under a stratum of clay, which prevents it from rising; the water in course of time, however, flowing in very varying quantities at different periods, gradually washes away small portions of the clayey band, when the sand above runs through into the cavity thus formed, leaving the pits described by the author. The mud-volcanoes at Tarl Dab he accounted for by supposing that after a fall of rain or snow the air contained in the water-bearing stratum would get churned up with water and mud, and be ejected as a frothy mud, sometimes to a height of three feet; while the brine-pits in the Karakash valley he believed to be formed by the excessive rise and fall in the level of that river at various times, which alternately fills and empties the bottoms of the pits, and the water left in the pits gets gradually concentrated by evaporation until a strong brine remains.

Discussion.—Mr. Prestwich pointed out that the pits seemed due to quite another cause than the pipes in the Chalk and other calcareous rocks, as they did not appear to arise from erosion by carbonic acid.

Mr. Thorp suggested an analogy between the phenomena in Yarkand and those at Nantwych, and thought that the pits might be due to solution of rock-salt below the surface.

2. "On the Cervidæ of the Forest-bed of Norfolk and Suffolk." By W. Boyd Dawkins, Esq., M.A., F.R.S., F.G.S.

The author described a new form of *Cervus* from the Forest-bed of Norfolk which he based on a series of antlers, and named *C. verticornis.* The base of the antler is set on the head very obliquely; immediately above it springs the cylindrical brow-tyne, which suddenly curves downwards and inwards; immediately above the brow-tyne the beam is more or less cylindrical, becoming gradually flattened. A third flattened tyne springs on the anterior side of the beam, and immediately above it the broad crown terminated in two or more points. No tyne is thrown off on the posterior side of the antler, and the sweep is uninterrupted from the antler base to the first point of the crown. The antlers differ in curvature and otherwise from those of *Cervus megaceros,* but there is a general resemblance between the two animals; and the *verticornis* must have rivalled the Irish Elk in size. A second species of Deer, the *Cervus carnutorum,* which had been furnished by the strata of St. Prest near Chartres, must be added to the fauna of the Forest-bed. The Cervidæ of the Forest-bed present a remarkable mixture of forms, such as the *Cervus polignacus, C. Sedgwickii, C. megaceros, C. carnutorum, C. elaphus, and C. capreolus,* seeming to indicate that in classification the Forest-bed belongs rather to an early stage of the Pleistocene than to the Pliocene age. This inference is strongly corroborated by the presence of the Mammoth, which is so characteristic of the Pleistocene age.

3. "The Classification of the Pleistocene Strata of Britain and

the Continent by means of the Mammalia." By W. Boyd Dawkins, Esq., M.A., F.R.S., F.G.S.

The Pleistocene deposits may be divided into three groups :—1st, that in which the Pleistocene immigrants lived, with some of the southern and Pliocene animals in Britain, France, and Germany, and in which no arctic mammalia had arrived; 2nd, that in which the characteristic Pliocene Cervidæ had disappeared, and the *Elephas meridionalis* and *Rhinoceros etruscus* had been driven south; 3rd, that in which the true arctic mammalia were the chief inhabitants.

This third, or late Pleistocene division, must be far older than any Prehistoric deposits, as the latter often rest on the former, and are composed of different materials; but the difference offered by the fauna is the most striking. In the Pleistocene river-deposits twenty-eight species have been found, the remains of man being associated with the Lion, Hippopotamus, Mammoth, Wolf, and Reindeer. On examining the fauna from the ossiferous caves, we find the same group of animals, with the exception of the Musk-sheep; and it is therefore evident that the cave-fauna is identical with that of the river strata, and must be referred to the same period. Some few animals, however, which would naturally haunt caves, are peculiar to them, as the Cave-bear, Wild Cat, Leopard, etc.

The magnitude of the break in time between the Prehistoric and late Pleistocene period may be gathered also from the disappearance in the interval of no less than nineteen species.

The middle division of the Pleistocene mammalia, or that from which the Pliocene Cervidæ had disappeared, and been replaced by invading temperate forms, is represented in Great Britain by the deposits of the Lower Brick-earths of the Thames valley, and the older deposits in Kent's Hole and Oreston. The discovery, by the Rev. O. Fisher, of a flint-flake in the undisturbed Lower Brick-earth at Crayford,[1] proves that man must have been living at this time. The mammalia from these deposits are linked to the Pliocene by the *Rh. megarhinus*, and to the late Pleistocene by the *Ovibos moschatus*. The presence of *Machærodus latidens* in Kent's Hole, and of the *Rh. megarhinus* in the cave at Oreston, tends to the conclusion that some of the caves in the south of England contain a fauna that was living before the late Pleistocene age. The whole assemblage of middle Pleistocene animals evinces a less severe climate than in the late Pleistocene time.

The fossil bones from the Forest-bed of Norfolk and Suffolk show that in the early Pleistocene mammalia there was a great mixture of Pleistocene and Pliocene species. It is probable also that the period was one of long duration; for in it we find two animals which are unknown on the Continent, implying that the lapse of time was sufficiently great to allow of the evolution of forms of animal life hitherto unknown, and which disappeared before the middle and late Pleistocene stages.

The author criticized M. Lartet's classification of the late Pleistocene or Quaternary period by means of the Cave-bear, Mammoth, Reindeer, and Aurochs, and urged that, since the remains of all

[1] See Geol. Mag., June, p. 268.

these animals were intimately associated in the caves of France, Germany, and Britain, and so far as we know, the first two appeared and disappeared together and the last two lived on into the Prehistoric age, they did not afford a basis for a chronology.

The latest of the three divisions of the British Pleistocene fauna is widely spread through France, Germany, and Russia, from the English Channel to the shores of the Mediterranean. The Middle Pleistocene is represented by a river-deposit in Auvergne, and by a cave in the Jura, in which the presence of the *Machærodus latidens* and a non-tichorine Rhinoceros, and the absence of the characteristic arctic group of the late Pleistocene and of all the peculiar animals of the early Forest-bed stage, prove that that era must be Middle Pleistocene. The early Pleistocene division is represented in France by the river-deposit at Chartres, being characterized by the presence of two non-Pliocene animals, *Trogontherium* and *Cervus carnutorum.*

The Pleistocene mammalia of the regions south of the Alps and Pyrenees present no trace of truly arctic species, the Mammoth being viewed as an animal fitted for the climatal conditions both of Northern Siberia and of the southern states of America. It contains *Elephas Africanus* and *Hyæna striata.*

The fauna of Sicily, Malta, and Crete differ considerably from that described above, possessing some peculiar forms, such as *Hippopotamus Pentlandi, Myoxus melitensis* and *Elephas melitensis.*

The Pleistocene mammalia may be divided into five groups, each marking a difference in the climate, the first embracing those which now live in hot countries; the second those which inhabit northern regions, or high mountains, where the cold is severe; the third those which inhabit temperate regions; a fourth those which are found alike in hot and cold; and a fifth, which are extinct.

There were three climatal zones, marked by the varying range of the animals. The northern, into which the southern forms never penetrated, the latitude of Yorkshire being the boundary of the advance of the southern animals; the southern, into which the northern species never passed, a line passing through the Alps and Pyrenees being the limit of the range of the northern animals; and an intermediate area in which the two are found mingled together.

Two out of the three zones are proved by the physical evidence of the Pleistocene strata.

We see by the discoveries of Dr. Bryce, Mr. Jameson, and others, that the Pleistocene mammalia must have invaded Europe during the first Glacial period before the submergence, for the Reindeer and the Mammoth have been found in Scotland under the deposits of the Boulder-clay. Dr. Falconer and others have also discovered the latter animal in the preglacial Forest-bed. The Glacial period can therefore no longer be looked on as a hard and fast barrier separating one fauna from another. If man be treated as a Pleistocene animal, there is reason to believe that he formed one of the North Asiatic group, which was certainly in possession of Northern and Central Europe in Preglacial times.

The Pleistocene mammalia may again be divided into three groups, those which came from Northern and Central Asia, those from Africa, and those which were living in the same area in the Pliocene age. Had not the animals which lived in Europe, during the Pliocene age, been insulated from those which invaded Europe, from Asia, by some impassable barrier, the latter would occur in our Pliocene strata as well as the former. Such a barrier is offered by the northern extension of the Caspian up the valley of the Obi, to the Arctic Sea. The animals of Northern and Central Asia could not pass westwards until the barrier was removed by the elevation of the sea-bottom between the Caspian and the Urals.

The same argument holds good as to the African mammalia, which could not have passed into Sicily, Spain, or Britain without a northward extension of the African mainland.

The relation of the Pleistocene to the Pliocene fauna is a question of great difficulty. If the Pliocene fauna be compared with that of the Forest-bed, it will be seen that the difference between them is very great. The Pliocene Mastodon and Tapir, and most of the Cervidæ, are replaced by forms such as the Roe and Red-deer, unknown until then; but many of the Pliocene animals were able to hold their ground against the Pleistocene invaders, although they were ultimately beaten in the struggle for existence by the new comers. The fauna which the author adopted as typically Pliocene is that furnished by the lacustrine strata of Auvergne, the marine sands of Montpelier, and the older fluviatile strata of the Val d'Arno.

Discussion.—Mr. Prestwich was hardly prepared to accept the proposed division of the Pleistocene mammalia into three groups; at all events so far as Britain was concerned. Neither could he draw that distinction between the beds at Erith and Grays and those higher up the Thames, which found favour with the author. The barrier offered by the river itself might to some extent account for the absence of Reindeer; and though there was a difference in the fauna in the two cases, it seemed hardly enough to mark any great distinction in time. As to the Hippopotamus, which occurred over the whole of Northern Europe, associated with the Musk Ox and large boulders, he could not see how the conclusion was to be escaped of its having been able to withstand greater cold than its present representative. Though the winters might have been colder, there was evidence in favour of the summers having been warmer; and the flora seems to have been much like that of the present day. The probable migrations of the different animal groups had already been pointed out by M. Lartet, though Mr. Dawkins had carried his investigation of the subject further. He called attention to the fact of the Mammoth having been found in Italy.

Mr. Charlesworth regretted that the author had not included within his province any of the marine Crag-deposits, some of which had been regarded as Pleistocene. In these beds the fish had been regarded by M. Agassiz as tropical in character, while M. Deshayes considered the molluscan remains as arctic. A similar discrepancy had been observed in other deposits of the same series, and he considered, therefore, that it was unsafe to generalize from any one series of remains, as, unless the whole fauna was taken into consideration, it was probable that erroneous conclusions would be arrived at.

Mr. Flower considered that the ossiferous caves and the river-deposits were separable and ought to be separated.

Mr. Evans observed that in generalizations of this kind not only the whole of the palæontological evidence should be taken into account, but the stratigraphical also. With regard to the author's middle division of the mammalia, he thought that eventually this would have to be modified. If it were to be maintained, there would be a great difficulty in accounting for the presence of the high beds at Shacklewell and High-bury, as these, though in a valley confessedly excavated by the river, and regarded as of more recent age than the lower beds, would yet be at a far higher level. Though accepting the probable existence of man in preglacial times, he pointed out that up to the present time the beds in Britain in which his works had been found were all postglacial.

Mr. Boyd Dawkins, in reply, stated that in forming his conclusions, he had not left out of view the evidence afforded by the classes of remains other than those of mammalia, but they threw no light on the classification. With regard to the middle of his divisions of the Pleistocene mammalia, he relied to a great extent on the presence of *Rhinoceros megarhinus*, and of a large number of Stags, to say nothing of the absence of Reindeer. He did not attach so much importance to the question of the level, as such descrepancies as those pointed out appeared to him by no means impossible. He gave his reasons for not regarding the Mammoth as an exclusively arctic animal. His remarks with regard to M. Lartet's classification referred rather to the expanded views of his followers than to those of M. Lartet himself. He acknowledged his obligations to Profs. Gaudry, Fraas, Rütimeyer, and Nilsson for various facts of which he had made use.

II.—June 19, 1872.—Prof. Ramsay, V.P.G.S., in the Chair.—The following communications were read:—1. "On *Trochocyathus anglicus*, a New Species of Madreporaria from the Red Crag." By P. Martin Duncan, M.B., F.R.S., V.P.G.S., Professor of Geology in King's College, London.

The author described a Coral of which a single specimen had been found in the Red Crag, in the grounds of Great Bealings Rectory, Norfolk. He stated that it belonged to the genus *Trochocyathus*, and was distinguished from the other species of that genus by its dense epitheca, its small and prominent columella, and its inverted calicular margin. He proposed to name it *Trochocyathus anglicus*, and stated that its nearest alliance is with the Australian Upper Tertiary form described by him under the name of *T. meridionalis*.

Discussion.—Mr. Prestwich inquired whether the fossil bore any resemblance to any of the French Eocene forms, and whether there was any possibility of its being derivative.

Prof. Duncan replied that the specimen was but little worn, and was therefore probably not *remanié*, though this point was not absolutely certain.

2. "On the Discovery of Palæolithic Implements in Association with *Elephas primigenius* in the High-terrace Gravels at Acton and Ealing." By Col. A. Lane Fox, F.G.S.

The gravels in the neighbourhood of Acton have been divided by Mr. Prestwich into two principal groups, viz. the high-level gravels on the hills above the valley, and the valley-gravels on the sides and bottom of the valley itself. The valley-gravels have been again divided by Mr. Whitaker into three terraces, viz. a high terrace, between 50 and 100 feet above the Ordnance datum, a mid terrace, between 20 and 40 feet high, and a low terrace, at an average height of 10 feet, occupying the low ground in the bends of the river. On both sides of the river the high terrace is separated from the mid terrace by a strip of the London Clay, which is laid bare at an average level of 50 feet. The London Clay is also laid bare on the sides of the tributary streams running into the valley on both sides of the river, thus dividing the high-terrace gravel into patches. The mid terrace is continuous, and follows the sinuosities of the valley on both sides up to the strip of London Clay. The author accounts for this distribution of the gravels by supposing that a large body of water must at one time have stood at the 50-feet level, and the denudation of the high terrace have been caused by the waves beating on the sides of the valley, and by drainage into this body of water. The mid terrace he conceives may have been caused in part by accumulations beneath this body of water.

The position of the high-terrace gravel at Acton corresponded so closely to that of the implement-bearing gravels of the Somme and the Ouse, that the author was led to examine carefully the excavations made in it for the construction of houses. He discovered a number of implements of the drift-type, together with flakes and cores, and a few roughly formed scrapers; all these were found in close contact with the London Clay, and beneath the gravel. Fragments of fern (*Osmunda regalis*) and of wood (*Pinus sylvestris*) were also found with the implements at the same level. Two implements were found at Ealing Dean, 2 miles westward, on nearly the same level as those of Acton, viz. 90 feet; and these also came from the bottom of the gravel. Another implement was found south of the river at Battersea Rise, in the same position above the strip of London Clay as at Acton, and about 60 feet above the Ordnance datum. The implements are of the pointed and oval types. The only animal remains discovered in the high terrace consisted of a tooth of *Elephas primigenius* in the Acton gravel. The position of this the author believes to be reliable, although he did not discover it himself *in situ.*

In the mid-terrace gravel a number of pits were examined between Shepherd's Bush and Hammersmith, and in the neighbourhood of Turnham Green, which resulted in the discovery, at the latter place, of a large quantity of animal remains (noticed by Mr. Busk in the following paper), all of which, like the implements of the high terrace, were at the bottom of the gravel; but no evidence of human workmanship was found in the mid terrace.

All these were found together, in the same seam of gravel, 12 feet beneath the surface, and all appeared to have been deposited at the same time. The surface was here 25 feet above the Ordnance datum, and consequently about 50 feet lower than the implements of the high terrace, 1½ mile to the north. The section across the valley, taken through the two places, here shows the strip of the London Clay intervening between the two terraces.

The chief points of interest which the author submitted to the judgment of geologists, consisted in the presence of drift implements in the high terrace, their presence in the mid terrace, and reappearance in the existing bed of the Thames; the great rarity or absence of animal remains in the high terrace, and their abundance in the mid terrace, and the occurrence of both implements and animal remains at the bottom of the gravel in both terraces. The writer concluded by adducing proofs of the great antiquity of the present river-bed, which it was shown must have run in its present meandering course in the bottom of the valley for at least 2000 years.

3. "On the Animal Remains found by Col. Lane Fox in the High- and Low-level Gravels at Acton and Turnham Green." By George Busk, Esq., F.R.S., F.G.S. The author described the mammalian bones referred to in the preceding paper.

The remains from the High-level Gravels at Acton belong to the genera *Bos*, *Ovis*, *Equus*, and *Elephas* (?). The greater part belong to the first-named genus, and are probably modern, as are also those of *Ovis*. The remains of *Equus* may be of greater antiquity. The other bones found may belong either to Elephant, Rhinoceros, or Hippopotamus; they include a large portion of an Elephant's molar, and are much rolled.

The remains from the mid-level gravel at Turnham Green generally present the characters of great antiquity. They include bones of *Rhinoceros hemitæchus*, *Equus caballus*, *Hippopotamus major* (one of them the left frontal of a very young animal almost unworn), *Bos* (probably *B. primigenius*, and some perhaps *Bison priscus*), *Cervus* (*C. Clactonensis*, Falc. = *C. Browni*, Dawk., *C. elaphus*, and *C. tarandus*), *Ursus ferox priscus*, and *Elephas primigenius*.

Discussion.—Mr. Prestwich complimented the author on the exactness and completeness of his description of the classical district which he had investigated, in which mammalian bones had been found and described by Mr. Trimmer so early as 1815. In that case Hippopotamus remains, very fresh and unworn, had also been discovered. Prof. Morris had also described a deposit near Brentford in which numerous remains of Reindeer were present, showing how variable was the distribution of mammalian remains even in a limited area, and how unsafe it was to base theories upon merely negative evidence. It was to be hoped that other investigators would extend similar discoveries to other parts of the valley of the Thames.

Mr. Godwin-Austen did not think that the presence of the young Hippopotamus was absolutely conclusive of its having been born in this country. With regard to the presence of remains of Reindeer and Hippopotamus in the same beds, not only might there have been an overlapping of fauna such as has been pointed out by Sir Charles Lyell, but there also might be an intermingling of the included remains from two beds of different ages. He was not altogether satisfied with the evidence as to the co-existence of man with *Elephas primigenius*, nor as to the artificial character of some of the presumed implements. He did not attach any great importance to the merely fragmentary bones.

Mr. Evans maintained that the implements exhibited were of necessity artificial, and commented on the nature of the evidence as to the co-existence of man with the Pleistocene fauna. Under any circumstances the gravels containing the implements could only have been deposited at a time when the Thames valley had not been excavated to anything like its present depth; and they were therefore of great antiquity. There was, moreover, a notable absence in them of a number of the animals usually found associated with Neolithic implements; and if man had not subsisted on the animals the remains of which were found associated with his handiworks in the gravels, it was a question on what food he had had to depend. The absence of implements in the low-level gravels seemed to him significant of a diminution in the number of the human beings who frequented the banks of the river.

Mr. Carruthers said that as the rhizome, whether it was that of *Aspidium* or *Osmunda*, was an aërial, and not a subterraneous rhizome, it must have been carried to its present position; and it consequently indicated, as Colonel Lane Fox had pointed out, the direction of the stream.

Mr. Flower regarded Col. Lane Fox's memoir as of great interest, as affording an additional instance of that perfect similarity of these deposits, whether in France or England, which in places so wide apart might reasonably be taken to indicate a common origin. It was indeed generally assumed that these deposits were brought down by rivers; but this, according to his view, was by no means certain. Col. Lane Fox had described the valley as 4½ miles wide; but there was at Croydon, 12 miles distant, a deposit of gravel capped with loess, containing elephant remains, and exactly resembling the Thames valley-gravels, and communicating with them. This evidently formed part of the Thames valley-system, whatever that system might be taken to be; and if so, he thought it incredible that the loess should have been distributed by river-action over an area 12 or 15 miles in width. In conclusion, he was quite content to adhere to the opinion held by the French geologists, and formerly by several of our own most able writers, that the distribution of these superficial drifts was in the first instance diluvial rather than fluvial.

Col. A. Lane Fox, in reply, pointed out the artificial character of the implements, and the manner in which the mammalian remains occurred. He thought that the lower terraces of gravel might have been formed at the bottom of a lake.

Mr. Busk, in proof of the animal remains not having been brought from a distance, showed that remains of the same animal were found in close proximity to each other.

Prof. Ramsay made some remarks on the undoubtedly artificial character of the implements, and on their position at the base of the gravels. The origin of the Thames valley he had already maintained to be of the Postmiocene age; and though there was at present no evidence of man's existence at that time, it was still possible. Of the extreme antiquity of the human race there could, however, be no doubt.

4. "On the Evidence for the Ice-sheet in North Lancashire and adjoining parts of Yorkshire and Westmoreland." By R. H. Tiddeman, Esq., M.A. Oxon, F.G.S., of the Geol. Surv. of Engl. and Wales.

The country of which the earlier glacial phenomena were described in this paper lies between the Lake-district on the north and the plains of South Lancashire and Cheshire on the south, and extends from the great watershed of England to the Irish Sea.

On the west is a sea-side plain rising to levels of less than 200 feet. On the north-east is a portion of the Pennine Chain, comprising Ingleborough, Pennigent, and other Fells, rising to heights of from 2000 to 2400 feet. Between these, from south to north, we pass over (1) a range of moorlands from 1000 to 1500 feet high, called the Rossendale Anticlinal, which forms the watershed between the basins of the Mersey and the Ribble; 2, the valley of the Burnley and Blackburn Coal-field, which drains north through gorges in (3) the Pendle chain of hills into (4) the broad valley of the Ribble; 5, a group of Fells rising to a general level of 1800 ft., between the valleys of the Ribble and the Lune, called for the purposes of this paper, "The Central Fells;" 6, north of this the valley of the Lune and the estuary of the Kent. The main direction of all these features, between the sea-side plain and the Pennine Chain, is from north-east to south-west.

The paper was illustrated by a map of the district on the scale of 1 inch to a mile, coloured to represent elevations, the level contours having been reduced from the 6-inch scale. Upon this all the ice-scratches found on the solid rocks were inserted. A diagram illustrating the proportional number of scratches in different directions showed that 20 per cent. of them were due south, although the general direction of the valleys was to the south-west.

An instance was mentioned of a ridge of 1400 feet in height, which had scratches at the top running directly across it to the south, although no land of equal height occurred north of it within a distance of seven miles. A similar instance was shown to exist on the ridge north-east of Pendle Hill. A *roche moutonnée* in the gorge of the Calder at Whalley was shown to have been formed by ice working from the north, although the river drains from the south.

Other systems of scratches were mentioned in detail. All these tended to show that, though the general slope and drainage of the district is to the S.W., the movement of the ice at the period of maximum cold was to the S. or S.S.E., or nearly parallel to the watershed.

The author goes on to describe certain disturbances at the surface of the rocks, which are dipping at high angles to the south, they having been overturned by some force coming from the north. Such surface-disturbances are not found on rocks dipping to the north; and this fact may be explained by an illustration: in one case the brushing was with the nap, in the other against it. It was shown that these phenomena could not be attributed to any other agent but a great ice-sheet pushing on from its northern gathering grounds, recruited by the greater elevations on its course, but overriding the lesser, grinding down and smoothing by its friction rocks presenting but a gentle incline, tearing up and turning over the basset edges confronting its approach.

The author next described the arrangement of the Till as to colour and material, and endeavoured to show that all the facts which he has observed are in favour of the existence of an ice-sheet travelling south in this district.

Mr. Cumming's observations in the Isle of Man were considered to confirm these views. He describes the general glaciation of the island as being from the E.N.E. or Lake-country, and describes many large blocks of granite which had been carried from their parent rock up the high hill of South Barruh and down the other side. This was referred by Mr. Cumming at the time to a great "wave of translation;" but the facts are quite easily explained by an ice-sheet. Other observations of Mr. Cumming upon the drifts of the Isle of Man were taken by the author as confirmatory of his views. Mr. Morton's observations on the glaciation of the Mersey basin were touched upon; and it was suggested that the glaciation of that district was produced by an ice-sheet, not coming from the south-east, as Mr. Morton holds, but working to the south-east from the Lake-country, and across a part of what is now the Irish Sea.

Professor Ramsay's observations on the glaciation of Anglesey being to the S.S.W. instead of from the Snowdon group, as might be expected, were considered by the author to be confirmatory of his views of a great ice-sheet having filled what is now the Irish Sea and emptied itself by St. George's Channel on the one hand, and by the Cheshire plain on the other, as well as by some of the passes in the Pennine Chain.

Discussion.—Prof. Ramsay regretted that the late hour of the evening prevented a proper discussion of this paper, which had been prepared with great care, and contained conclusions of great importance and novel observations.

5. "On the Mammalia of the Drift of Paris and its Outskirts." By Prof. Albert Gaudry, F.C.G.S. (In a letter to W. Boyd Dawkins, Esq., M.A., F.R.S., F.G.S.)

In this paper the author briefly indicated those mammals the remains of which have been discovered in the Pleistocene or Quaternary deposits of Paris and its vicinity. His list includes flint implements as evidences of the existence of man, and bones of the following species :—*Canis lupus*, *Hyæna crocuta* (*spelæa*), *Felis leo* (*spelæa*), *Castor trogontherium* and *fiber*, *Elephas primigenius* and *antiquus*, *Hippopotamus amphibius*, *Rhinoceros tichorhinus* (a Rhinoceros of doubtful species), *Sus scrofa*, *Equus asinus* and *caballus*, *Bos primigenius*, *taurus ?*, and *indicus ?*, *Bison priscus* and *Europæus*, and *Cervus tarandus*, *Belgrandi*, *megaceros*, *Canadensis ?*, *elaphus*, and a small species.

Geologists' Association.—June 7, 1872.—The Rev. T. Wiltshire, President, in the Chair.—1. "On the Classification of the Cambrian and Silurian Rocks," by Henry Hicks, Esq., F.G.S.

The author, after mentioning the groups now known to comprise the Cambrian and Silurian Rocks, as exhibited in the British Isles, and the usual mode, hitherto, of dividing and sub-dividing these formations, stated that it was impossible, in a science so progressive as Geology, where new discoveries were continually being made, to accept at present any of these arrangements, which for the most part had been made some twenty or thirty years ago, unless with considerable modifications. The classification approved by the author has already been, to a great extent, adopted by Sir Charles Lyell, in his "Student's Manual," and by the late Mr. Salter and the author in papers to the British Association, and is based on the most recent palæontological and stratigraphical evidence. In a table exhibited for the purpose of illustrating these facts, the classification of Prof. Sedgwick and of Sir Roderick Murchison were placed side by side along with the one proposed.

The columns in the table showed (1) the lithological characters of the beds comprising each group, (2) the thickness of the strata, (3) the organic remains contained in each group, (4) the number of genera and species which are known to reach from one group into another, (5) the order of the appearance of animal life upon the globe, and (6) the localities where the several groups are best seen in England.

By means of the evidence set forth in these columns, the author was enabled to show the most natural divisions and sub-divisions, so far as recent researches are capable of explaining them.

The following are the chief divisions, accepted as being the most satisfactory at present:—The *Lower Cambrian*, to include the Longmynd (Harlech grits and Llanberis slates, and the rocks at Bray Head, etc.), and the Menevian groups, which were shown to be intimately connected palæontologically, and to be entirely distinct in their faunas from the overlying rocks.

The *Upper Cambrian*, to include the Lingula Flags (Lower, Middle, and Upper—called also Maentwrog, Ffestiniog, and Dolgelly or Malvern) and the Tremadoc groups. These were also shown to be connected closely by some of the genera, especially by *Olenus*, *Conocoryphe*, and *Dikelocephalus*.

The *Lower Silurian*, to comprise the Arenig (Lower and Upper, the former a series only recently known through the researches of the author, and forming a connecting link between the Tremadocs and the true Arenig rocks), the Llandeilo (Upper and Lower, the former being black shales or slates, and the latter calcareous), and the Bala or Caradoc groups.

The *Upper Silurian*, to consist of the Llandovery (Upper and Lower), the Wenlock and the Ludlow groups. The whole of the Llandovery group was placed in the *Upper Silurian*, in accordance with the evidence cited by Prof. Ramsay in his memoir on North Wales, along with the facts explained by the table, and which went to prove that when it was to be separated entirely from the other groups, as a Middle Silurian division, this was the most natural and proper position.

2. "On the Silurian Rocks of the English Lake-district," by Prof. Alleyne Nicholson, M.D., D.Sc., M.A.

In this paper the author classified the Silurian rocks of the English Lake-district as follows, commencing with the lowest:

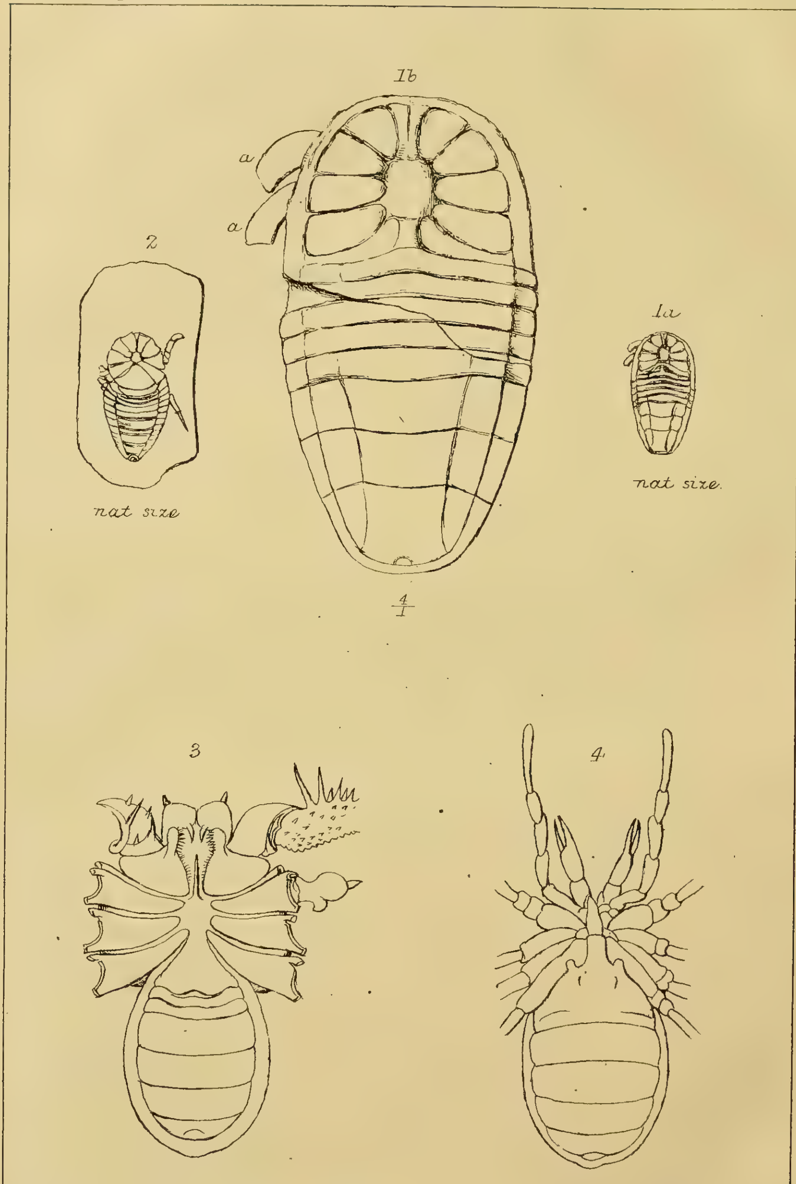
1. The Skiddaw Slates.
2. The Borrowdale Series, or Green Slates and Porphyries.
3. The Coniston Limestone and Associated Shales.
4. The Graptolitic Mudstones.
5. The Coniston Flags.
6. The Coniston Grits.
7. The Kendal Rocks.

Each of these members of the series was described lithologically and palæontologically, and its geological position discussed, not only with reference to the other beds of the district, but also to the Silurians of Wales and North America.

MISCELLANEOUS.

Mode of Extracting Fossils from Limestone.—Most geologists in the course of their studies have met with hard compact limestones, which show, when broken, the profiles of fossils, but are too hard or too homogeneous to admit of their obtaining any fossil out of them, so that sometimes it is impossible to ascertain their age. The following method may be of some use for obtaining fossils out of such limestones:—Burn the limestone. Prepare a saturated solution of borax (borate of soda) in hot water; let it cool somewhat (from 50 to 70 degrees Celsius), and put the cooled limestone into it, taking care that it continues to cool. There is then formed hydrate of soda (caustic soda) and borate of lime, which is not liable to alteration by the influence of air and water. One or two days, according to the size of the piece of limestone, will be sufficient for the chemical transformation. Take care that the solution is not too hot and completely saturated, otherwise the caustic lime may be destroyed, as by the action of pure water. The limestone becomes softer, looks as if it were weathered, and allows the fossils to be cut out easily. The results are not so good if the limestone is more or less crystalline or contains calc-spar, because it breaks up by the heat, and for this reason the limestone may be also destroyed.

Marburg, Germany. A. von Koenen.



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A new Arachnide.

from the Coal Measures Lancashire.

THE

GEOLOGICAL MAGAZINE.

No. XCIX.—SEPTEMBER, 1872.

ORIGINAL ARTICLES.

I.—On a New Arachnide from the Coal-measures of Lancashire.

By Henry Woodward, F.G.S., F.Z.S.,
Of the British Museum.

(PLATE IX.)

It is now twelve months since I had the pleasure to record, in the pages of this Journal, the discovery of *Eophrynus Prestvicii*, a new genus of Arachnides from the Coal-measures of Dudley. (See Geol. Mag., 1871, Vol. VIII., p. 385, Pl. XI.) This remarkably perfect specimen is perhaps unequalled in the condition of its preservation by any Palæozoic fossil known. Although the fossil Arachnide, which forms the subject of this notice, cannot claim such distinction as *Eophrynus*, yet it is well deserving of being placed on record in the pages of this Magazine, as a new genus of air-breathers from the English Coal-measures.

A short time since I received, through the kindness of Mr. Thomas Birtwell, of Gawthorpe Gardens, Padiham, Lancashire, a series of very interesting Crustacean remains from the Ironstone of the Coal-measures of that county.

My attention was especially directed to two specimens marked by Mr. Birtwell as "parts of the body of a beetle," which I perceived upon examination to be the remains of an Arachnide.

The most perfect specimen (which measures 16 millimetres in length, and 7 mill. in greatest breadth) exposes the entire surface of the body, save that the anterior cephalic portion adheres to the intaglio half of the mould, whilst the relievo exhibits the bases of four pairs of limbs, and a pair of palpi, less distinctly seen, arranged in a semicircle, with their wedge-shaped basal joints directed towards the centre.

Next follow four extremely narrow, nearly straight, (thoracic) segments, with slightly rounded borders; succeeded by three large (abdominal) segments, these last forming together nearly half the entire length of the body, and having a well-defined double margin with two slightly raised and nearly parallel lines, which traverse them in a longitudinal direction, and divide the inner part of each segment into three parts. The three segments contract rapidly in breadth backwards, so that the third and most posterior segment, which is rounded near its extremity, is only half the breadth of the most anterior one. On reaching the last segment, the two nearly parallel longitudinal lines turn slightly outwards, and terminate on its lateral border. The last segment bears the efferent aperture on its under surfaces. No ornamentation is visible on any part of the specimen.

I was at first inclined to believe this singular Palæozoic fossil to be quite new and undescribed; but on turning to Mr. S. H. Scudder's "Supplement to the Description of Articulates, being a Description of Fossil Insects found on Mazon Creek, and near Morris, Grundy Co., Illinois," contained in Mr. A. H. Worthen's Report on the Geological Survey of Illinois, vol. iii. (Geology and Palæontology), 1868, I found, on p. 568, an obscure figure of an *Arachnide,* from the Coal of Illinois (reproduced on our Plate IX.), which I believe to be generically identical with the Lancashire specimen above described.

I subjoin Mr. Scudder's remarks thereon:—"The last of the nodule-specimens (see Pl. IX., Fig. 2) is perhaps the most interesting. I believe the remains to be those of an Arachnide. This is the first discovery of a fossil spider in America, and, as far as I know, only the fourth instance of the occurrence of *Arachnidæ* in Carboniferous strata. In 1835 and 1839, Corda first figured two species—one a true Scorpion, the other a gigantic Pseudo-scorpion. Recently, Roemer has described a true Spider, under the name of *Protolycosa.* Thus, the three known Carboniferous *Arachnidæ* represent three distinct families of Octopods. The one figured here (*Architarbus rotundatus*) seems to belong to a fourth family, being allied to the *Phalangidæ* and to the *Phrynidæ.* In its fragmentary state, one can scarcely judge with certainty of its exact relationship. The arrangement of the legs accords equally well with both families. The broad attachment of the thorax to the abdomen is a phalangidan characteristic, while the size and shape of the abdomen, the number of the abdominal segments, and the crowded state of the central portions of the basal ones, indicate closer affinities to the *Phrynidæ.*

"The under surfaces of the thorax and abdomen are exposed to view, together with a fragment of one of the legs. The thorax is nearly circular; the arrangement of the coxæ uniformly radiate; the two joints of one leg are of equal length, and broader at the apex than at the base.

"The abdomen is nearly as broad at the base as the thorax; it broadens close to the base, and beyond is ovate. The first abdominal segment is scarcely perceptible at the sides; very large in the middle, crowding downwards the four succeeding segments, which are short and bowed. The terminal three segments are long and straight, the last having just at the tip, but on the under surface, the circular anal opening. Laterally all the segments are depressed, and thus a broad flat border is formed on either side. Length of specimen, $18\frac{1}{2}$ mill.; length of thorax, $8\frac{1}{2}$ mill.; breadth of the thorax, 9 mill.; greatest breadth of abdomen, 9 mill.; length of the longest abdominal segment, $1\frac{1}{2}$ mill.; length of one leg-joint, $3\frac{1}{4}$ mill.; breadth of the flattened margin of abdomen, $\frac{3}{4}$ mill."

From the foregoing description, and also by a comparison of the figures (1 and 2 on Pl. IX.), it will be seen how closely the American and English forms of this small Arachnide agree with one another. There is sufficient distinction, however, to prevent their being placed under the same specific appellation. I have therefore named Mr. Birtwell's *Architarbus subovalis*.

It is interesting to observe how many of these old forms of life from the Carboniferous series of North America occur also with us, under similar conditions of fossilization, in the Clay-ironstone nodules of our English Coal-measures.

We already possessed, in common with North America, a small King-crab (*Bellinurus*), occurring in Clay-ironstone nodules; three Myriapods, namely, *Xylobius sigillariæ*, *Euphoberia ferox*, and *E. Brownii*; now we may add an Arachnide almost identical with that from Illinois.

EXPLANATION OF PLATE IX.

FIG. 1. *Architarbus subovalis*, H. Woodw. In a Clay-ironstone nodule from about 4 feet above the "four-feet mine," or "bone-coal," Coal-M., Lancashire.
1*a*. *A. subovalis*, natural size.
1*b*. „ magnified four times.
FIG. 2. *Architarbus rotundatus*, Scudder. Coal-M., Grundy Co., Illinois, U.S.
FIG. 3. *Phrynus reniformis*, Oliv., (recent), ventral aspect of body.
FIG. 4. *Phalangium cornutum*, Lin., (recent), ventral aspect of body ♀. Placed for comparison with *Architarbus*.

[For a complete list of the Fossil Insecta, Myriapoda, and Arachnida, see my article on *Eophrynus Prestvicii*, GEOL. MAG., 1871, Vol. VIII., p. 385, Pl. XI.]

II.—NOTICE OF THE OCCURRENCE OF *CUPRESSOCRINUS* IN A QUARRY OF DEVONIAN LIMESTONE NEAR KINGSTEIGNTON.

By JOHN EDWARD LEE, F.G.S., F.S.A.

THE genus *Cupressocrinus* is very characteristic of the Devonian formation in Germany. In some parts of the Eifel it may be called common; and yet in England, though equally characteristic of the same formation, and though it has been found in several places, yet it is considered so rare that it is hardly mentioned by many of the writers on the Devonian fossils. In Morris's Catalogue the localities given are Plymouth and (somewhat strangely) Collumpton, where there is no Devonian limestone. For these reasons it may be worth recording that there is one small and somewhat insignificant quarry between Newton and Teignmouth, where fossils of this genus occur in abundance, though unfortunately generally in the state of casts.

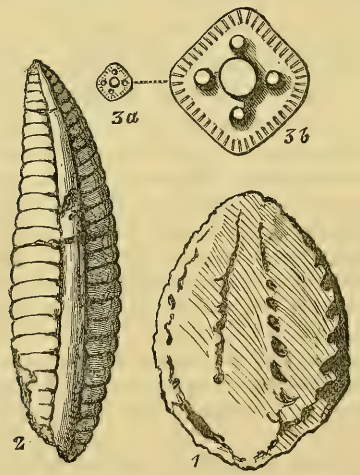
The quarry is about a hundred yards north of the road which connects these two towns, near a farm called the Lower Wear. This farm is between Kingsteignton and Bishopsteignton.

A bed of trap here cuts off a small portion of what is usually considered as Middle Devonian limestone, and has so altered it near the junction, that the stone has become a reddish-coloured cinder. The crinoidal remains, consisting chiefly but not entirely of *Cupressocrinus*, are here very abundant, though in the adjacent unaltered limestone, in which they are probably equally abundant, they are much more difficult to be distinguished.

The stems and joints of this genus are so very well marked that almost the smallest fragment cannot be mistaken. Both the larger and smaller stems are subquadrangular, with a larger central perforation surrounded by *four* smaller ones. In the specimens found in this quarry most of them are in the shape of casts; the fossil itself having entirely disappeared, and the perforations, and in some cases the divisions of the joints, having been subsequently filled up, the effect is frequently like that of a Norman pillar with small pillars clustered round it, the thin plates representing the divisions of the joints, looking like the layers of mortar between the beds of tooled stone in the Norman pillar. (See Woodcut, Figs. 3*a* and 3*b*).

In some rare cases there are five pillars clustered round the large one instead of four, though the stem is still of rather a square form. These specimens are considered by Quenstedt to belong to a distinct species, which he calls *Cup. pentamerus* (Handbuch der Petrefaktenkunde, page 747, plate 71, figs. 14 and 15); probably, however, it may be only a variety.

Besides these stems and joints, three or four fossils were found associated with them in the same quarry, which at first sight seemed to be of very different character, but which may probably be portions of the heads of *Cupressocrinus*. They are figured upon the accompanying Woodcut. (See Figs. 1 and 2.)



Figs. 1 and 2. Crinoidal remains associated with
Figs. 3*a* and 3*b*, casts of the stems of *Cupressocrinus*.

These fossils are not remarkable either for size or beauty; but, as they are decidedly very characteristic of the Devonian formation, and have hitherto been considered rare in England, it may be desirable to record their occurrence. In a small specimen of the rock not three inches long there are five well-marked examples very distinctly shown.

III.—On Rock-Staining.

By J. Clifton Ward, F.G.S., Associate of the Royal School of Mines; Of the Geological Survey of England and Wales.

In a paper on "The Permian Beds of Yorkshire," Mr. Lucas[1] maintains: 1st, that the present western edge of the Magnesian Limestone, at all events to the north of Ripon, marks the old shore-line; 2nd, that the iron and other salts found in Permian deposits were derived from the neighbouring grit and limestone land; 3rd, that the colouring-matter, as it was brought down, stained the rocks forming the bed of the inland sea, and hence the purple and red colour of the grit and other beds between Knaresborough and Leeds. A few words may be said upon each of these points in turn.

1. The Magnesian Limestone boundary, for some miles to the north and south of Leeds, certainly has not the appearance of having been the actual western shore-line of the limestone sea, since it forms, in most parts, a long low escarpment facing west, and there are outliers at various distances, up to two miles, from the main mass. North of Ripon, however, Mr. Lucas shows the facts to be otherwise; and here it is interesting to think that it may be possible to mark out approximately the old coast-line.

2. If the Millstone-grit and Coal-measure rocks formed the neighbouring land, undoubtedly much iron would be carried into the sea by the streams and rivers, supposing the strata then to have been in much the same state of consolidation and mineralization as now. They must certainly have been exposed to much pressure and alteration, as well as denudation, in the formation of the Pendle anticlinals.[2]

3. Mr. Lucas "cannot avoid the conclusion that the date at which the Plompton grit received its purple colour was during the deposition of the earliest red sediments below the limestone, and that the carbonate of iron sank into the Plompton grit from Permian waters, and not from subsequent infiltration from colourless limestone." Now, strangely enough, in this particular neighbourhood, where the red grit and shale beds are mostly found, there were *no* red beds deposited below the limestone, but it in all cases rests directly upon Millstone-grit or Coal-measure strata;[3] whereas north of Ripon, where Mr. Lucas says the red colour is not generally found, the Marl Slate *does* come on beneath the limestone.

The question therefore arises, is the colour belonging to the rocks themselves, or has it been produced through changes due to percolation from the overlying limestone?

First, as regards the shales of the Lower Coal-measures. These,

[1] See Geol. Mag. (August, 1872), Vol. IX., p. 338.

[2] Mr. Lucas speaks, by inadvertence, of the east and west anticlinals as the Pennine, whereas the Pennine anticlinal, ranging north and south, was post-Permian in its formation, and helped to give the easterly tilt to the Magnesian Limestone.—See Prof. Hull's paper, Quart. Journ. Geol. Soc., vol. xxiv., p. 323.

[3] See my paper "On Beds of *supposed* Rothliegende Age, near Knaresborough," etc. Quart. Journ. Geol. Soc., vol. xxv., p. 291.

near Barwick-in-Elmet, immediately beneath the limestone, are sandy, micaceous, and purplish, the purple colour being quite unknown to me among the Lower Coal-measures, although I have mapped them almost continuously from Sheffield to Leeds. Further south, sandstones and shales belonging to the Middle and Upper Coal-measures are in places similarly stained beneath the limestone escarpment. The Plompton grit is felspathic and micaceous; generally, between Knaresborough and Collingham, of a purple tint, and readily crumbling through the action of the atmosphere. Where it has an east and west strike, and passes away westwards from the limestone, it loses the purple or red colour. Mr. Lucas has stated (p. 342) that "only one and the same bed is found to be purple," whereas, besides the Coal-measure shales described above, some of the beds beneath the Plompton grit exhibit a tendency to like colouration. To quote from my paper,[1] "Below this (Plompton-grit) come some 50 feet or less of such shales as generally occur in the Millstone-grit series, followed by a sandstone, gritty in some parts, and generally of a reddish colour, though not so markedly coloured as the last-mentioned grit; this rock, which may average some 75 feet in thickness, passes down into sandy and flaggy shales, in many parts having a tendency to be both gritty and of a purplish tint."

These general facts led me to infer that either the colouring-matter contained in the grit and shale beds was unusually brought out,—that is, that the iron in them was more than ordinarily peroxidized,—by some local cause, or that colouring-matter had been introduced by some local cause. Now the only cause I know of is the neighbourhood of the Magnesian Limestone, and its having formerly overlapped these very beds. The opinion that this was the main cause seemed, moreover, to be strengthened by the fact that *generally* the purple colour was *most* developed along a line immediately beneath the limestone, though in some cases the colour is quite absent even there. I have stated it as my belief that the colouration "is chiefly due to the peroxidation of iron; and this, it seems to me, may take place in two ways: either by the action of carbonated water from the limestone above filtering through porous grits and sandstones, and converting the protoxides contained in them into sesquioxides; or by iron being brought from the overlying limestone, in the form of hydrate and carbonate, and redeposited in the rocks below." Prof. Ramsay considers the last explanation the most probable.[2] Prof. Sedgwick says,[3] "Hydrate of iron appears to form the colouring-matter of many of the yellow beds of limestone." Prof. Phillips believes[4] the purple colour to be due to decomposed ferruginous mica, and the absence or presence of mica in the different parts of the same beds of grit or shale might thus account for the absence or presence of colouration. This decomposition of the mica, or other chemical changes occurring in the rocks, might take place,

[1] Quart. Journ. Geol. Soc., vol. xxv., p. 293.

[2] "On the Red Rocks of England of older date than the Trias." Quart. Journ. Geol. Soc., vol. xxvii., p. 242.

[3] Transactions of the Geol. Soc., 2nd series, vol. iii., p. 239.

[4] "Notes on the Geology of Harrogate." Quart. Journ. Geol. Soc., vol. xxi., p. 234.

more or less, merely by the action of the atmosphere, but such changes would probably be much helped forward and increased by the infiltration from above of carbonated water, together with the hydrate and carbonate of iron. Hence it should not surprise us that a porous, readily-weathered grit should assume the purple colour in places far removed from limestone agency; though the fact, that the purple colour is most common where there has decidedly been a limestone overlap, seems to support the view here maintained.

Mr. Lucas has mentioned a number of sections in which the limestone rests on unstained rocks; but such are evidently exceptions, when it is considered that for several miles the limestone immediately overlaps red rocks, and that these had in the first place been mapped as possibly belonging to the Permian, until further evidence showed how clearly they were of Millstone-grit and Coal-measure age. I have alluded to the non-colouring of beds in places as due to the following reasons:[1] "1st. Changes in mineral composition of the rocks to be coloured: thus some grits contain much red felspar, others but little; some sandstones and shales contain more mica and more iron oxides diffused through them than others. 2nd. Changes in composition of the overlying limestone. 3rd. Differences in the porosity of the underlying rocks, some withstanding the infiltration of the carbonated water more than others. With regard to this third point, one would naturally expect, as is the case, that permeable grits would be coloured to a greater thickness than impermeable shales; while such a rock as the Calliard, mentioned as occurring near Barwick-in-Elmet, being so flinty and close-grained, might resist the percolation altogether, and accordingly it is found to be quite uncoloured, although its joints are lined with carbonate of lime. The upper parts of the coloured shales would likewise become marly by reason of the calcareous matter deposited within them."

Mr. Lucas makes the strange statement that the Magnesian Limestone "does not colour the fields red, when free from drift;" but surely the drift in those parts takes its nature very largely from the rocks beneath: there is little or no red drift-clay on Coal-measure or Millstone-grit ground near Leeds, while it is found at once upon the Magnesian Limestone area; and Prof. Ramsay says,[2] "The Magnesian Limestone soil is always red."[3]

In conclusion, Mr. Lucas states (p. 343), "Were Mr. Ward's explanation the true one, the lower limestone ought certainly, at least here and there, to be reddish." But since the iron is chiefly in the form of hydrate ($2Fe_2O_3{\cdot}3H_2O$), it could not be expected to impart a red colour, except where, exposed to the atmosphere, it becomes anhydrous red peroxide (Fe_2O_3) and forms a red soil; or when, as carbonate ($FeCO^3$), soluble in excess of carbonic acid, it is carried away from the limestone and redeposited as red peroxide, the carbonic acid being liberated. The black oxide ($FeO{\cdot}Fe_2O_3$), Prof. Sedgwick says, is also constantly associated with the yellow limestone.

[1] Quart. Journ. Geol. Soc., vol. xxv., p. 296.
[2] Quart. Journ. Geol. Soc., vol. xxvii., p. 242.
[3] On Mr. Aveline's working copies over the Lower Magnesian Limestone, I find many notes of "red soil" and "red clay."

IV.—On the Formation of Deltas: and on the Evidence and Cause of Great Changes in the Sea-Level during the Glacial Period.[1]

By Alfred Tylor, F.G.S.

Part I.

THE first portion of this paper is devoted to a comparison of the Delta deposits of the Po, Mississippi, and Ganges, by means of the descriptions of the strata obtained from borings in their Deltas for water. The surfaces of these Deltas, and the alluvial plains above them, are compared together, with reference to their height above the sea and inclination, and it is found that a parabolic curve drawn through the extremities of each river, and through one point in its course, nearly represents its longitudinal section,—the greatest deviation being 30 feet in some of the largest Deltas. The Delta deposits are found to be coarser and more sandy near the bottom, and indicate more rapid rivers and greater rainfall at the earlier portion of their history.

Messrs. Humphreys and Abbott's descriptions of the Delta of the Mississippi are compared with those of earlier writers, and a description is given, from their work, of the late extensions of the Delta into the Gulf of Mexico.

The formation of Delta deposits is explained by the hypothesis of a change in the level of the sea instead of in the level of the land and sea bottom.

The littoral deposits around Great Britain are investigated by the author, to ascertain if the hypothesis of a fall in the sea-level of 600 feet during the Glacial Period is tenable.

Some evidence of the extent of the Glacial Period is given, and the ice-cap hypothesis advocated by Mr. Croll is alluded to as a probable cause of a great reduction in the level of the sea through abstraction of water from the sea and its deposition at the Poles in the form of ice.

The positions of the fossiliferous strata of the Quaternary Period are discussed with relation to Mr. Godwin-Austen's former suggestion of a great river where the German Ocean now is, formed by the junction of the Rhine, Thames, and Humber. The probable age of the Straits of Dover is also alluded to.

Professor Forbes's examination of the Fauna and Flora of the British Isles, with a view to the determination of the sources of Alpine plants, induced him to believe that the British plants and animals migrated from Scandinavia, Germany, and France, at different periods, some before and some after the Glacial Period, and the

[1] Being the text in full of a paper read by the author before the Geological Society of London, November 11, 1868, but only published in brief abstract in the Quart. Journ. Geol. Soc., 1869, vol. xxv., p. 7.

The views embodied in this paper received little favour at the time of their first enunciation; but having since been adopted by some geological writers, the author is desirous that the full text of his paper (as delivered to the Geological Society in 1868) should be made known, in order that his claim to priority may be recognized.

hypothesis of a fall in the sea-level seems to accord better with the facts he described, than his supposition of changes of level of the land and sea bottom.

If the hypothesis is correct, that there has been a fall of the sea-level of 600 feet during the Glacial Period, followed by an equivalent rise, we ought to find evidence of dry land, of rivers, or at least of littoral conditions, on the bottom of the sea within the 100 fathom line of soundings.

We should not expect to find a very continuous and unbroken land-surface preserved, as in the upward movement of the sea much ground would be covered with deposits of clay, and shingle, and sand, and much of the old surface removed by currents and waves.

De la Beche, Edward Forbes, and Godwin-Austen have investigated the present condition of the sea-bottom round the British Isles, and in their writings are to be found many observations of facts that may be as conveniently explained by the hypothesis of the change in the sea-level as by that of a change in the level of the land and sea-bottom.

Mrs. Somerville writes (p. 219, Physical Geography): "By soundings during the Coast Survey of the United Kingdom, it appears that Great Britain and the innumerable islands and rocks that rise above the surface of the sea repose upon a submarine bank, bounded by a line 100 fathoms deep; and this bank, on which Great Britain and all its islands stand, is connected on the south-east through Holland and Belgium with the Continent of Europe."

Sir H. T. De la Beche (page 192, Theor. Researches) remarks:—"If the British Islands were elevated one hundred fathoms above the level of the ocean, and thus joined to the Continent of Europe, they would be surrounded by an extensive area of flat land: for the fall from the old sea-coasts to the new sea-coasts would be generally so gradual as to present to the eye one great plain."

In the Quart. Journ. Geol. Soc., vols. vi. and vii., 1850 and 1851, Godwin-Austen gave maps of the English Channel and German Ocean, and records littoral accumulations, mammalian remains, and freshwater shells in situ, although at depths reaching nearly to 100 fathoms. He boldly mapped out a diagram of the course of a great ancient river which ran 400 miles north, receiving the waters of the Rhine, Thames, Humber, Tweed, and Tay, having its mouth near the 100 fathom line between the coast of Scotland and the entrance to the Baltic Sea. Plate 7, vol. vii., Quart. Journ. Geol. Soc., 1851. He also produced evidence of the former course of the river from soundings, and by the presence of fossil mammalia dredged up from near its course. He records that Captain White dredged up *Unio pictorum* between the 50 fathom and 100 fathom line off the mouth of the English Channel, and that marine gravel banks (with littoral shells), formed at the surface of the sea, are now lying under sixty or seventy fathoms of water in the same locality (p. 96, vol. vi. Quart. Journ. Geol. Soc., 1850). In vol. ii. Quart. Journ. Geol. Soc., p. 117, Mr. Godwin-Austen records beds of peat or turf being dredged up off the coast of France—Pas de Calais—by fishermen.

Taking the facts as they stand in the writings of these authors, who have all treated the subject most skilfully, the hypothesis of a gradual fall in the sea-level of 600 feet I think explains them equally well, or better, than that of local elevations, or than depressions to exactly the same point. The great difficulty in Forbes's chain of argument was to get the Scandinavian flora across the sea. It was necessary to suppose that the space now occupied by the German Ocean was elevated (of which there is no proof), in order to provide dry land for the plants to pass over. The glacial mollusca were found by Forbes living in the deeper portions of the German Ocean, which, I think, showed that there could have been no great elevation of the sea-bottom. Whether the sea-level were reduced or the land raised 600 feet, would have the same effect in producing changes of climate and increased excavating power of rivers; and I think all the phenomena of a great northern river receiving the waters of the Rhine, Thames, Humber, etc., would occur as described by Mr. Godwin-Austen, if the sea-level were depressed 600 feet.

Mr. Godwin-Austen states that the level of the Red Crag strata and of the Thames Valley was, at the period of the Red Crag, at about the same level as it is now. See plate in vol. vii., page 136, Quart. Journ. Geol. Soc., 1851. But he tells us that the land in question has undergone great oscillations in the intervening period, and has returned to its old level. p. 136, vol. vii., Quart. Journ. Geol. Soc., 1851.

No proof of such a movement is offered, and it would appear as if Mr. Godwin-Austen suggested such oscillations of level principally to justify him in attributing an arctic climate to this part of England, such climate being indicated by the terrestrial flora and marine fauna, and subaerial gravel in the Quaternary Period. Now the hypothesis of a great fall in the sea-level and subsequent rise of the water to the same point would, I think, explain satisfactorily the occurrence of great subaerial beds of gravel with fluviatile and terrestrial remains, without the necessity of supposing an immense elevation of England and a subsidence afterwards to exactly the same point.

I say exactly, because the Crags and fossiliferous gravel deposits are situated on a very narrow and level horizon. A fall in the land, now, of fifty feet, would immerse every portion of the Red and Norwich Crags, and of the fossiliferous gravels containing *Cyrena*. The Coralline Crag is found a few feet higher than the others.

The top of the Red Crag and of the Cyrena sands in the Thames and Humber Valleys reach the same height within three or four feet, and are all under the 50 feet range of height at the present time.[1]

Then on the English south coast and at Sangatte there are raised beaches occupying similar positions as to level as the Crag in the German Ocean, and containing erratic boulders at their base as in the Red Crag.

[1] Searles Wood, in a letter to A. Tylor respecting the height of the Crag.

Mammalian remains have been found at the Brighton raised sea-beach within the 50 feet level. The shells in the raised beaches in the English Channel not being of Arctic forms, is presumptive evidence that the Straits of Dover were not open at the raised beach period.

No one can see the great valley of the Somme, or the Dover Valley, without being convinced that in the Quaternary Period these wide and deep valleys, excavated out of solid chalk, were filled by large rivers.

I would propose to continue Godwin-Austen's great river up to the Somme, and the Dover river down the space now occupied by the English Channel, at the period when the Atlantic only reached the present 100 fathom line on our coasts, and when the spaces now occupied by the German Ocean and the English Channel were dry land. During the Glacial Period of 160,000 years (?), there would have been ample time for the river Somme and the Dover river, draining land relatively 600 feet higher than at present, to have excavated wide valleys where the Straits of Dover are now situated. Under a cold climate, such as the South-east of England would have been, removed so far from the Gulf-Stream, and reaching an elevation of 1400 feet above the sea at the close of the cold period, after a very extensive denudation, we might expect the whole of the South of England to have been denuded very rapidly. The chalk is now covered by vegetation, and the atmosphere acts slowly upon it; but wherever it is suddenly exposed to the air and cold, it crumbles away with great rapidity. The chalk hills resting upon beds of sand and loose clay, exposed to a very wet and cold climate, at elevations between 600 feet and 2000 feet above the sea, would be rapidly denuded. The abruptness of the escarpment of the North and South Downs, and the steepness of the curves of denudation, give an exact measure of the force of the cold and pluvial action upon strata (of different powers of resistance and elevation), situated on either side of the watershed, the apex of the curves. Cold and rain, those active agencies of denudation, have operated upon strata differing in their pervious or impervious qualities in relation to lines of drainage in mineral character, in inclination to the horizon, and in distance from the points of drainage to the highest point of land (determining all intermediate levels), and have given these escarpments their present outline.

The Dover river has its source in a valley commencing within a few yards of the steep escarpment of the chalk, only separated by a few yards from the edge of the Chalk hills down which water flows in the opposite direction, following a binomial rather than a parabolic curve.

In passing from a watershed in any direction to the sea, or to the bottom of a valley, the slope of the ground gradually increases and then gradually decreases until it reaches the still water. This form or outline at the surface can be expressed by a binomial curve of some kind on any line of section. This is therefore the theoretical curve of denudation of which the author has already spoken. See

p. 392. These curves vary on the two sides of a watershed with the respective inclination flexures and difficulties of the strata and position with regard to drainage. The curves vary particularly with the projection of harder beds and retreat of softer beds from the theoretical line (Quetelet, p. 413. Lettres, etc., Curves shown, 1846).

The slope of the bottom of the Dover Valley is about 385 feet in 7 miles, or 1 in 55. The Somme drains a more extensive area, and is a larger and slower river. It contains along its course, and near the level of the present river, fluviatile deposits with *Cyrena fluminalis.* As this shell is found fossil abundantly in the Thames and Humber rivers flowing into the German Ocean, it seems probable that the Somme river, since it is inhabited by the *Cyrena fluminalis,* drained into the German Ocean, and not into the English Channel—the *Cyrena* is found in no other river draining into the English Channel. The Varne shoal, between Dover and Calais, would appear to mark the former watershed of the Somme and Dover rivers.

Sir H. T. De la Beche examined the soundings in the Channel, in order to see if the large valleys which opened on to the coast-line were continuous under the sea. He found they were not now to be traced, but I think this is no proof that they did not exist.

The action of the sea may have filled up the deeper portions of the valleys with deposit, and abraded the old watersheds lying between the systems of valleys formed when the space occupied by the Channel was dry land. The measure of time for partly excavating and filling up the Channel valley may be represented by that requisite for the denudation of the Wealden area and the south of England.

Prior to the Glacial Period we should expect that there was high land between Dover and Calais, and that when the German Ocean and English Channel became dry this land was lowered immensely by fluviatile and pluvial denudation.

The work of the sea in opening out the Straits of Dover would be much facilitated if the space between Dover and Calais had been previously perforated by two large rivers, and still more by the action of their tributaries and by rainfall, during a period which has been supposed by astronomers to have lasted 160,000 years. All over the south of England there is evidence of subaerial and pluvial gravel reaching nearly to the summit of the hills, and the character of the debris and the size of the now dry valleys and character of the watershed indicate the kind of climate which existed in the south of England from the time of the elevation of the Wealden area nearly to the historical period. The unsymmetrical flexures in the Wealden and Cretaceous Beds show the *exact* direction of the elevatory force, which was *oblique*[1] to the *horizon* and to the *Channel,* bending the strata in a double oblique system, by the author's measurement. The uneven surfaces of the Palæozoic rocks[2]

[1] Mr. Hopkins treated the force as vertical, and did not observe flexures.

[2] The most favourable situation for boring for coal is between Fairlight Glen and Crowboro Beacon.

below would transmit pressures unequally along the axial line and at right angles to it, on account of varying rigidity, and would account for unequal elevation to some extent along the axial line of greatest elevation.

The tides would rise much higher at the extremity of both the English Channel and German Ocean before the perforation of the Straits of Dover than they do now, and a rise of tide in the Thames and Somme equal to that in the river Wye would explain many difficulties.

When the breach off Dover was made sufficiently wide to unite the two seas, the tide would not rise to its former height, and this would give the appearance of the sea-beaches along the coast having been raised, and not that of the sea-level being lowered.

The shingle flats near Calais and at Dungeness are analogous in character and level.

The Antwerp Crag and the true Norwich or Mammaliferous Crag are also at a very low level and near the present estuaries.

The shells in a well-section at Permerunde, North Holland, observed by Mr. Burnell in 1852, were marine, but there was evidence of an old land-surface at 56 feet below high-water mark, and this seems to match the level of the submarine forests all round the British coasts, and the sections in Cornwall in which Colenso found tin-stone gravel, mammalian and human remains, below the later marine or estuary deposits (page 407, De la Beche, Devon and Cornwall).

At Pentuan, Cornwall, human remains, skulls, are stated to have been found under 40 feet of detrital accumulations, also mingled with the remains of deer, oxen, hogs, and whales (page 404, op. cit.). Mr. Colenso describes a piece of shaped wood, on the upper part of the silt, that reposes upon the remains of a submarine forest, the trees of which have grown upon the tin ground. Remains of man mingled with those of deer and other animals were found at Carnon, among wood, leaves, and nuts, 53 feet below the river-wash (see also Geological Transactions, vol. iv., 1817, p. 404).

Section at Carnon Stream Tin Works:—

1. Mud and sand, 7 feet
2. Granite-gravel, intermingled with small pieces of a substance resembling charcoal and a few shells, 3 feet.
3. Fine gravel, mud, and shells, 12 feet. About this depth several beds of oysters, 4 or 5 feet in thickness, extending irregularly to within 4 or 5 feet of the tin ground.
4. Closer mud intermingled with shells. In this stratum have been found several branches and trunks of trees cut with an axe or sharp instrument, horns, and bones of stags, likewise human skulls.
5. Tin ground, varying from 1 to 6 feet. The shells correspond with those found in the Falmouth Estuary.

Mr. Ray Lankester informs me that at Antwerp the Black Crag is below the level of high-water, reposing on Eocene Clay. The top of the Yellow Crag is within 20 feet of the level of high water.

The *Cyrena* beds of St. Valery and Abbeville are also within 50 feet of high-water mark.

Different opinions prevail as to the relative ages of these Crags, fluviatile, and estuary gravel beds (containing fossils), raised beaches and tin-stone gravels covered with marine remains, on account of their different organic contents. As far as regards position merely, all these deposits are now on one horizon, and the circumstance of some beds being deposited before the Glacial Period and before the fall of the sea-level, and others at the close of the Glacial Period, may explain their being on one horizon, and apparently almost continuous, although really separated by an immense interval of time; no change having taken place in the level of the land, but great oscillation in the sea-level having occurred in the Glacial Period.

Mr. Gwyn Jeffreys has lately recorded[1] the discovery of specimens of fossil littoral arctic shells off the Shetland Isles, in about 90 fathoms of water. The following species were found by him in dredging, and are arranged in the order of their abundance:—

Terebratella Spitzbergensis.
Rhynchonella psittacea.
Pecten Islandicus.
Tellina calcarea.
Mya truncata, var. *Uddevallensis.*
Trochus cinereus.
Molleria costulata.
Trophon clathratus.
Pleurotoma pyramidalis.

All these shells, I believe, are found fossil in Sweden and living in the extreme Arctic seas. None of these species are ever found in deep water, so that their presence scattered over a wide area of sea-bottom is remarkable, and corresponds with the discovery of shingle and littoral shells in the English Channel at similar depths. The littoral shells in the English Channel are not of Arctic forms, like those in the German Ocean, and this is a proof that they were deposited on the sea-bottom of the English Channel before the junction of the English Channel and German Ocean at the Straits of Dover was effected.

The discovery of these 9 species of fossil shells, by Mr. Gwyn Jeffreys, at a depth of 90 fathoms, off the Shetland Islands, is an important addition to Forbes' and Godwin-Austen's observations. This discovery affords independent and corroborative proof of identical conditions with those observed by them in other parts of the sea-bottom, and it establishes the existence of littoral conditions near the present 100 fathom line during the Quaternary Period in the North Sea, and is therefore an additional support to the hypothesis we are considering. A fall in the sea-level of 600 feet would not only produce littoral conditions off Shetland, without any change of level of the sea-bottom, but would tend to lower the temperature of the air very much, and also to increase the rainfall. There are certain conditions under which a rainfall of 300 inches per annum might be produced in our climate, but this would involve the summer heat being 130° Fahrenheit near the locality of a mountain range of 1,500 to 2,000 feet. The amount of rainfall depends greatly upon the elevation of the temperature of the air at the sea-level (supposing it saturated with moisture), and the low temperature of the air on the mountain range intercepting the aerial currents.[2]

[1] Brit. Assoc. Reports, Dundee, 1867, p. 431.

[2] Abstract "On Loess of the Valleys of the South of England and the Somme." Geol. Journ., p. 504, vol. xix., 1863.

We might have in our latitude a summer heat of 130°, from the general elevation of the heat of the globe, from an increased volume of the Gulf-Stream, and from a greater prevalence of the west and south-west winds.

The Pluvial Period which I proposed, and which was so much objected to in the discussion of my paper,[1] does not require any greater volume of water than has been before suggested by geologists. I find that heights of 80 feet were proposed for the ordinary difference of winter and summer floods, in passages of two different memoirs by Mr. Prestwich, as occurring during what he considers the earlier part of the Gravel Period.

There is, however, in England, no appearance of tropical vegetation in the Quaternary deposits, such as we should expect would accompany a temperature of 130°, and we must therefore try one of the other alternatives.

We could not have rivers varying 80 feet in summer and winter without some such rainfall, except we have pluvial and tidal conditions very different from those now in the Thames and Somme Valleys. What we want is to explain the enormous rise of rivers in a cold climate during the Quaternary Period. In the year 1840 the ice brought down by a January flood gorged at a point about 9 miles from the mouth of the Vistula, and cut a channel through the sand hills to the sea. This is now the mouth of the Vistula, that passing Dantzic, has been turned into a canal.[2]

I do not intend here to discuss the question of subsidences and elevations, which have affected the surface of the earth so largely, and have no doubt occurred in some localities during the period under consideration. I would, however, remark that in Wealden, Eocene, or Miocene Deltas is there any instance of any large fluviatile deposit having been elevated or depressed *evenly* over a large area; while all over the world a perfectly even movement of subsidence is supposed to have taken place, just at the mouths of large rivers, in the Quaternary or most recent period, in order to account for modern freshwater Delta deposits containing shells living in the adjoining seas, being now found hundreds of feet below the sea-level.

(*To be concluded in our next number.*)

V.—Glacial Drift of the Central Part of the Lake District, up to 2800 feet above the Sea.

By D. Mackintosh, F.G.S.

(Author of Articles on the Drifts of the Borders of the Lake District.)

During five and a half weeks' examination and study of the glaciated rock-surfaces and drifts of the south-central part of the Lake District, in June and July last, I was fortunate in meeting with many fresh and clear sections in diggings for house sites, drains,

[1] See Quart. Journ. Geol. Soc. Lond., 1868, May 10, vol. xxiv. pp. 455–6.

[2] Pfeffer, "On the Vistula," Dantzic, 1849. The gorging of ice at the mouth of the Thames, Seine, and Somme may have assisted in the production of some of the remarkable gravel-beds in these rivers.

gravel-pits, tracks of unusually large rain-torrents, etc., which enabled me on some points to arrive at a more satisfactory classification of the drifts of the country than I had previously succeeded in devising.

Traces of a Great Valley-ignoring Ice-stream.—It was not long before I found myself constrained to return to the doctrine advocated in "Scenery of England and Wales"—namely that a stream of land-ice must once have assailed the central part of the Lake District from the N.N.W.,—a stream of sufficient thickness and possessed of sufficient force to enable it to march over the irregular plateau between the Stake pass and Dunmail Raise—to glaciate the valleys and ridges obliquely or directly across, from Far Easdale (if not from a more northerly latitude) to Morecambe Bay, and over a breadth of country extending from the upper part of the two Langdales and the Coniston Old Man in the west, to Kentmere in the east—the direction of the mammillation and primary striation within this district ranging between N. and N.W., the general direction being about N.N.W. This great ice-stream smoothed nearly all, if not all, the *roches moutonnées*, from the splendid series on the top of the ridge (up to 1700 feet)[1] between Easdale and Great Langdale, down to the bosses in the two Langdales, Grasmere, Easdale, Rydal, Ambleside, Windermere, and Old Man valleys, and those situated on the watershed between Windermere and Stavely, and to the S. of Windermere and Bowness. This valley-ignoring, or rather Lake-district-ignoring ice-stream (for it treated high ridges as subordinate obstructions), would appear to have ground down a great part of the country during its uphill, downhill, and across-dale progress.[2] But the comparative absence of smoothed and glaciated stones at high levels, even where the *roches moutonnées* are strikingly developed, and the uniformly smooth (excepting where weathered) and curvilinear character of the *roches moutonnées*, would seem to indicate that the rocks were mainly ground down by grit adhering to the base of the ice, and that the large loose blocks the ice met with in its course were either reduced to finer matter or jammed up in abrupt recesses. If we except boulders more than nine inches or a foot in average diameter, not one stone out of ten in the Pinnel of the central parts of the Lake District is distinctly glaciated, whereas in the marine boulder and brick clays of Cheshire, at least one stone out of three is decidedly flattened, grooved, or scratched.[3] These facts would

[1] I found very distinct striæ pointing N.N.W. at a point more than 1600 feet above the sea on this ridge. Lower down, the direction of the rock-smoothing and striæ *crosses* the outlets of Easdale and Blind Tarns.

[2] This ice-stream must have so smoothed and rounded the cliffs and rocky projections as to prevent their shedding much scree-matter for a long time afterwards, and if to this consideration we add the possible disappearance of glaciers from the larger valleys soon after the ice-sheet vanished from the immediately surrounding plains (for even the inner ends of these valleys often lie lower than the plains), we shall see reason for expecting to find comparatively little subaërial moraine-matter represented among the drifts of the Lake District.

[3] In some parts of the Lake District where the smaller stones are fine-grained and not very hard, the proportion exhibiting scratches is greater, but even then the stones are scarcely ever much flattened or regularly grooved.

seem to show that floating coast-ice is the great glaciator of stones, while land-ice is the great grinder and smoother of solid rocks.

Clay- and Gravel-Pinnel or Sammel.—I have lately seen upwards of a hundred clean sections of this formation from 134 up to 2800 feet above the sea. It consists of clay, loam, or sand, intermixed with numerous stones from the size of a pin's head up to one foot or sometimes a foot and a half in average diameter, boulders of a larger size being very exceptional. The stones are nearly all more or less blunted, some of them considerably rounded, but most of them subangular. The stones chiefly lie or stand at various angles, but not unfrequently exhibit a tendency to a curved linear arrangement. We almost invariably find the stones less and less rounded the higher we ascend the hill-sides—a fact (as above hinted) not very easily reconciled with the idea of their having been distributed by the great ice-sheet which ignored hill and valley. In the two kinds of pinnel, the clayey ("waxy") and the sandy or gravelly, the stones are *similarly* distributed; and both kinds (but especially the latter) frequently present the appearance of being rudely stratified in the form of a series of curves or arches, occasionally varied by a rough interwedging of beds. The waxy pinnel often contains seams, beds, or pockets of sand.—Pinnel may be found in nearly all positions. It fills up crevices and recesses in the rocks, chokes up brook courses, clings to steep as well as gently-rising hill-slopes, and covers plateaux and broad ridges at various levels; but the greatest masses are associated with angular or mammillated rocky projections which would appear to have arrested it in its forward movement. In such positions it forms undulating terraces, and gently-swelling large oblong knolls which generally run along the sides or middle of the larger valleys, or diversify broad low-level passes. The colour of the pinnel is usually yellowish brown, sometimes grey, especially when dry.

Pinnel on Helvellyn.—On the W. side of a great part of Helvellyn there is a flat terrace which slopes transversely from about 1900 feet up to 2100 feet. It is more or less covered with drift, the greater part of which, I believe, is true pinnel. West of the top of Helvellyn, a steeper slope at a higher level runs up to 2800 feet, where a sudden rise of the ground marks its termination. At this point (which is only a few hundred yards from the top of the mountain) I was fortunate in finding a newly-cut drain apparently intended to divert a part of the water of the celebrated Brownrigg well to a mine at a lower level. Under a covering of stony loam I saw a clear section of typical clayey pinnel, and afterwards found pinnel in brook sections lower down, so that the upland extension of this deposit to at least 2800 feet above the sea may be regarded as certain. But as pinnel, especially clayey pinnel, could only have been formed directly or indirectly by ice-action, the former extension of either land or sea-ice (possibly both) to this great altitude can scarcely be doubted.

Pinnel Hillocks and Surface Blocks.—In inland valleys and upland cwms, on passes between hills, and on cols or depressed parts of ridges, the pinnel (containing many small blunted or slightly rounded stones, and some glaciated small boulders, but no large angular blocks) often surrounds or is associated with projecting bosses of rock, in the form of small detached or semi-detached hillocks, or groups of hillocks, as in Great Langdale, Upper Rydal, and Kentmere valleys, Easdale and Blind Tarn cwms (Grasmere), Dunmail and Kirkstone passes, etc. Clear sections of these abrupt hillocks[1] generally reveal as good pinnel as that composing the large gently-swelling knolls of the wider valleys, with this difference that the hillocks, or rather the hollows between them, are much more dotted with large angular blocks (including split blocks), which, however, are *confined* to the surface, or to a thin covering of loamy débris,[2] with the exception of a few connected with the underlying rocky nuclei. The surface-blocks are probably "droppings" from rafts of coast-ice, or from small icebergs (derived from high-level glaciers) which in general did not float very far before parting with their loads,[3] as these blocks are chiefly found in inland or upland districts at no very great distance from cliffs which break up into large fragments. At the mouths of cwms (as in the case of Coniston Low Water) on the sides of inland valleys (as near Seathwaite), there are often ridges, or rows of angular blocks, which are evidently the *subaërial* moraines of small *post-marine* glaciers, but they belong to a period distinct from that of the pinnel hillocks which most observers have mistaken for moraines. An eminent Scotch glacialist inclines to agree with me in regarding such hillocks as a more abrupt form of Till or Boulder-clay knolls.

General Section of Drifts (Blue Clay omitted) from the Central part of the Lake District to the plains on the S. or W. 2. Pinnel or Sammel, graduating into Lower Boulder-clay outwards. 3. Stony Loam progressively replaced outwards by stratified Sand and Gravel. 4. Upper or Brick-clay.

The red stony loam which generally (not always) covers the pinnel in the Lake District, is often the merely weathered part of the pinnel; but after a number of observa-

[1] I have examined about twenty sections of these pinnel hillocks, the two most complete being near Elterwater Village, and Dunmail Raise Cottage.

[2] This débris has partly determined the shape of the smaller and less regular hillocks.

[3] In some instances large surface blocks, as well as the smaller boulders imbedded in the underlying drift, must have been floated to great distances from the Lake District.

tions on hill-slopes, I could not give up the belief that the loam (especially where the imbedded stones are angular, and still more especially where the loam is associated with large angular blocks) is what Victor Hugo would call a "veritable construction." I now however believe that this stony loam is not the equivalent of the brick-clay of the plains of the N.W. of England, but that it is on the horizon of the part of the middle sand and gravel which is found on the hill-sides, or on the borders of the hills. That the eskers of Ireland and kames of Scotland were piled up during some part of the Middle Sand and Gravel Period can, I think, scarcely be doubted; and I now see reason for believing that the second submergence which I have supposed necessary for the accumulation of the upper or brick clay of the plains was of very limited extent, and that this clay seldom rises higher than 400 or 500 feet above the present sea-level—the boulder-clay at higher levels in Lancashire, Yorkshire, Cheshire, and the Welsh borders, being the equivalent of the pinnel of the Lake District.

The drifts of Scotland and the N.W. of England cannot, I believe, be correlated without regarding the English upper or brick clay (above which there are no eskers or kames) as the representative of the Scotch shelly clay. My pinnel may possibly represent both the till and boulder-clay of Mr. James Geikie; and the more ancient blue clay of the N.W. of England and Wales may be on the horizon of the lower or dark till of Swedish geologists.

VI.—Notes on the Roslyn Hill Clay Pit.

By the Rev. T. G. Bonney, M.A., F.G.S.

(Read before the Cambridge Philosophical Society, May 13, 1872.)

THIS pit has already formed the subject of communications to the Society. In one read February 16th, 1863, and in a subsequent paper published in the Geological Magazine, Vol. II., p. 529, Mr. Seeley maintained, as I believe Professor Sedgwick had always held, that the singular juxtaposition of Kimmeridge Clay, Cretaceous rocks, and Boulder-clay, was due to faulting. In 1868 the Rev. O. Fisher communicated a paper, in which he accounted for the phenomena, by considering the Cretaceous beds as a huge boulder-like fragment, dropped into a valley which it had excavated in the Kimmeridge Clay, with the intervening space filled up with Boulder-clay. Shortly after this had been read, Mr. Seeley published a paper in the Geological Magazine (Vol. V., p. 347), in which he attacked Mr. Fisher's view.[1] The explanation of the phenomena may therefore be fairly regarded as still *sub judice*. During the last three years I have from time to time visited the pit, and purpose to lay before the Society the conclusions at which I have arrived, from repeated comparison of the rival theories with the sections exhibited during the progress of the works.

The pit is an irregular excavation with its longer diameter lying roughly East and West, its shorter North and South. The northern

[1] Mr. Fisher's paper was printed subsequently, Vol. V. p. 407.

side shows a cliff of nearly horizontal Kimmeridge Clay, which at the western end is capped by a little Upper Neocomian, generally more or less disturbed. A small step, some three feet high, may be observed here in the Kimmeridge Clay, marking probably some inequality in the process of erosion. This Kimmeridge Clay extends about half-way round the western end of the pit, and we then find a fine exposure of Boulder-clay, the junction of the two being indicated by springs, but masked by boggy talus overgrown with brushwood. Near the south-western angle we again come upon the Upper Neocomian sands; then we have, after an interval of broken ground, a little Chalk, Upper Greensand with phosphatic nodules, Gault, some Boulder-clay, and Kimmeridge Clay, which forms the greater part of the southern wall of the pit. Finally, on the eastern side we have Boulder-clay, Gault, Upper Greensand, Chalk, as before, and then an opening. The annexed sections (Figures 1–4)

SECTIONS OF PIT.

FIG. I.

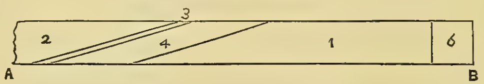


FIG. II.

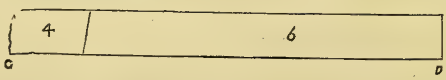


FIG. III.

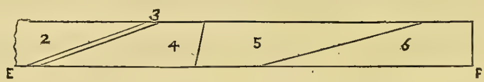
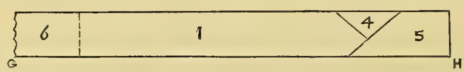


FIG. IV.



For explanation of reference numbers see Fig 5. In Figs. 1–3 the sections commence on the southern side and do not extend across the whole pit.

will, I hope, make this above-mentioned strange succession of beds more intelligible than a long verbal description. They relate to three portions of the pit:

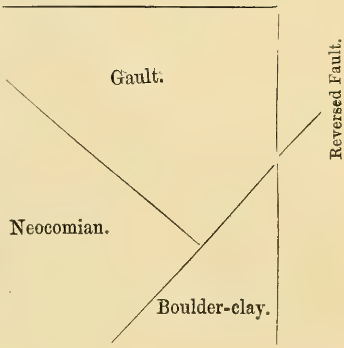
(1). The south-western corner, Fig. 4.

(2). The middle of the southern side, Figs. 2 and 3.

(3). The south-eastern corner, Fig. 1.

On the eastern face of the angle which terminates the cliff of Boulder-clay we have at the top a mass of Gault about seven feet thick. Its bedding appears to dip (but this is very faint) towards the left and into the cliff. The mass is rather cracked, and shows internal slickensides in two directions; one, to some extent parallel with its lower boundary, the other roughly vertical and at right angles with the surface. It contains many phosphate nodules and fossils, *Perna*, *Belemnites*, etc. The Boulder-clay dips clearly under this (as shown), and exhibits a faint stratification parallel with its surface, for some depth. The uppermost layer is very chalky, like some of those below, and the surface shows slickensides. Its left hand extremity is covered by a talus. Two or three yards to the right is another smaller mass of Gault, apparently disconnected and inclosed in Boulder-clay (possibly re-arranged). This rests with an irregular base on brown (Neocomian) sand, and the upper part of this sand is full of small flattened nodules of soft clay with carbonaceous markings and fragments of shells, resembling some of the Weald clays. These soft sands, after about a couple of feet, rest on sandstone and hard conglomerate of small pebbles. The whole appears to dip sharply towards the pit-floor, and I believe has slipped down from above.

In brief then this section gives us (even if we suppose that the second fragment of Gault became detached from the first during the possible re-arrangement of the neighbouring Boulder-clay, and that the Gault and Neocomian are dipping in the same direction and conformable,—which I do not believe) a reversed fault of about 45°, bringing the Boulder-clay under the Gault and Neocomian: as shown in the annexed diagram, which is drawn as seen in the cliff.



Passing along grass-grown talus on the south side of the pit, we find this too much masked to make out clearly the relations of its component strata. There is much Neocomian rock scattered about, and the wetness of the bank shows that clay is very near the surface. Some of this (at any rate near to where a small mound of white earth may be an evidence of the former presence of Chalk-marl) is probably Gault.

We then come to a spur projecting from the south side of the pit, where the Chalk-marl is still left; and discover below it the Upper Greensand seam, with the Gault in sequence (phosphate nodules and fossils), and beyond this Upper Neocomian resting apparently on Kimmeridge Clay. I have repeatedly examined this section (Fig. 3); and from comparison of my notes and drawings have come to the following conclusions:—That the Kimmeridge Clay just at this spot is not horizontal, but dips into the pit at an angle of some 15 degrees; that the Upper Neocomian beds which dip at much the same angle are disturbed, shattered, and to some extent mixed with Boulder-clay; that the Gault is not conformable with the former, but that the plane of junction dips at an angle of not less than 60°, and that the strike is not quite the same; that the Kimmeridge Clay and Neocomian beds have come into this position by slipping down from above, as the clay in the wall of the pit is horizontally stratified. If however these beds were brought into their present position by

[1] If further proof were needed, I found on one occasion a mass of chalky Boulder-clay, some two feet in diameter, included in the Kimmeridge Clay, just above the floor of the pit.

faulting, accompanied by a dragging down near the fault, an ordinary "downthrow" would be required here, not a reversed fault.

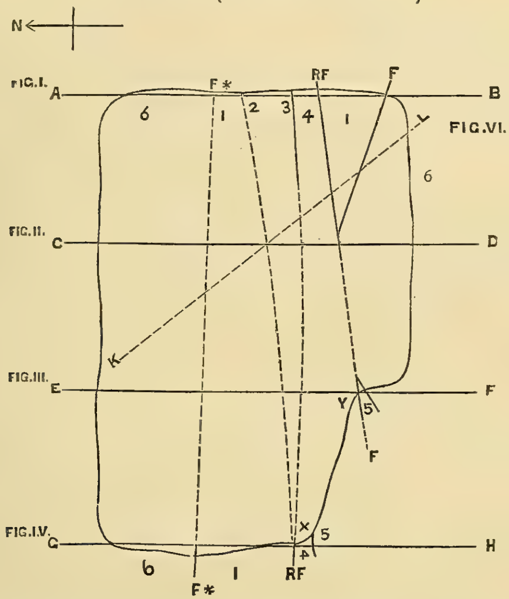
Passing eastwards along the wall of Kimmeridge Clay, we now and then notice a slight appearance of dragging down, which of course would be compatible with either a fault or a line of old cliffs, from which slips had taken place on to the bed of a valley; but as the beds forming the floor of the pit show no traces of any disturbance, I consider this as no evidence for the fault hypothesis. At the south-east angle we have the sequence represented in Fig. 1. Beginning at N. end, the Lower Chalk, marly, and showing traces of bedding, distinctly dips at an angle of about 30° to N., the Upper Greensand with phosphate nodules and characteristic fossils is in its usual place below, and the Gault (with many phosphatic nodules and fossils) below that; *and then the Boulder-clay distinctly dips under it at about the same angle.* Here then, if there be a fault, we have a still more singular case of a reversal. The Boulder-clay, on the occasion of my last visit, showed most singular contortions,[1] various chalky and sandy layers being crumpled up in the strangest manner. The clay at the southern end is full of blocks of Neocomian sandstone, which from their position have evidently slipped from above. Mr. Seeley's section of this end of the pit (Geol. Mag. Vol. V., p. 348) is certainly wrong; the Brown sand which, with superjacent Gault, he brings down between the Kimmeridge Clay and Boulder-clay at the S. corner is not *in situ*, but has fallen from above. I have no doubt on this point, as I have watched the section for nearly four years, and seen that the Neocomian stratum was merely a number of boulders included in the clay, and on the last occasion almost all of them had been removed. I can only explain the mode in which these blocks occur by supposing, that before and during the accumulation of the Boulder-clay, there was nearly along the line of the south side of the pit a cliff or bank of Kimmeridge Clay, capped by Neocomian rock, from which fragments slipped and fell.

We will now turn back a short distance. About a year ago I was fortunate enough to see a large portion of the pit-floor in the south-east corner laid bare (which is now converted into a pond). This showed me the Gault resting on the Boulder-clay, and the latter in apposition, as described above, with the Kimmeridge Clay, without the intervention of any Neocomian sand. I also saw a large fragment (several cubic feet) of Kimmeridge Clay included in the Boulder-clay near the south-east corner. On examining the floor of this new excavation, I found that the Kimmeridge Clay and the Gault gradually approached one another, so that at about 60 paces from the end of the pit they met, as represented in Fig. 2; this might still be seen when I was last there, in a bank which had been left for a dam. Laying down the results of these four sections (Figs. 1—4) on the sketch-plan (which does not pretend to be much more than a diagram, the form of the pit being very irregular in its minuter details), and

[1] This crushing appears very local, because on other occasions it was far less marked; and I do not regard it as in any way indicative of a fault, rather such as might be caused by melting of included ice-blocks or local settlements.

assuming for a moment the 'fault' hypothesis, we have the results represented in Fig. 5. The course of the fault (F*) is conjectural, as this part of the pit is under water. Yet with all this strange jumble, the Kimmeridge Clay on either side of the pit is undisturbed and as nearly as possible horizontal!

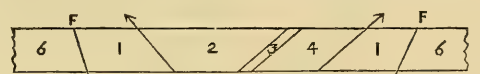
FIG. V. (PLAN OF PIT FLOOR.)



EXPLANATION.—1. Boulder Clay. 2. Chalk. 3. Upper Greensand. 4. Gault. 5. Neocomian. 6. Kimmeridge Clay. The dotted lines represent those parts of the outcrop of the junctions of the different beds on the pit floor, which cannot be exactly followed. The interval between A B and C D is about 60 paces, and the same distance is between C D and E F. F, Fault. R.F, Reversed Fault. The sections are not drawn to scale.

Supposing, however, that the irregular occurrence of the Neocomian beds is due to denudation before the deposition of the Gault,—supposing that, owing to a north-easterly dip (which is quite compatible with the facts), the Chalk disappeared just before reaching the south-west, and the Gault widened out in the same direction, so as to cap all the space from X to Y:—supposing, in a word, every possible simplification (that I can conceive) introduced—still a section taken across the line K L will give us the collocation represented in Fig. 6, in which the direction of the arrow indicates the 'throw.'

FIG. VI.



I conclude, therefore, that this arrangement is so extraordinary that it renders the fault theory in the highest degree improbable. We are accordingly driven to consider this mass of Cretaceous rocks, as either slipped from above, or dropped as a boulder of a gigantic size into a pre-existing valley. Though no doubt there have been slips from the cliffs on the south bank of this valley, I do not think that we can very well explain the position of this mass of Chalk, especially at the south-east corner, on the first of these theories. Moreover, I do not think that we anywhere find the Gault conformable with the Neocomian sands; the former appears to me to be of variable thickness, and to be merely the base of the great fragment to which it is attached, seeing that it rests, now on Boulder-clay, now on Kimmeridge Clay, now on (disturbed) Neocomian sand.

But it may be said there is no precedent for such a huge transported mass. Mr. Seeley ridicules the idea (Geol. Mag., Vol. V., p. 347); although he quotes in a former paper (Geol. Mag., Vol. I., p. 150) a case of a very large mass of Chalk, 180 feet long, included in the Boulder-clay of Norfolk. Mr. Fisher also (Geol. Mag., Vol. V., p. 409) mentions, without measurements, some other masses which are evidently very large. But in the Quart. Journ. Geol. Soc., vol. ix., Prof. Morris describes a boulder in the Lincolnshire drift (which according to his account much resembles that at Ely, even to its showing traces of stratification and an upper and lower division) in the following words (p. 320):—"Emerging from the south end of the tunnel on the Great Northern Railway, which is 880 yards long, we see the drift on either side of the cutting, buoying up an enormous irregular mass of Oolitic rock, through which the cutting has passed; this mass is 430 feet long, and at its deepest part 30 feet thick." He says, "that the beds, though broken and disturbed, retain to some extent their relative positions, and belong to the lower part of the Oolitic rocks of the district." And this statement Prof. Ramsay indorses (Quart. Journ. Geol. Soc., vol. xxvii., p. 252), calling the boulder 380 yards in length; stating also that Mr. Judd has discovered large masses of erratic marlstone, and that Prof. Geikie is of opinion that the Lias of Linksfield is also an erratic.

Hence the boulder theory, startling as it may seem at first sight, appears to me to present far less difficulty than that which accounts for the phenomena by a series of faults. The facts which I have brought forward are in my opinion very strongly in favour of Mr. Fisher's hypothesis; and my only excuse for bringing the subject under the notice of the Society is that as left by him it was rather an hypothesis than a demonstration; more facts were wanted, and these time has, I hope, enabled me to supply. To sum up briefly, the question now stands thus:—(1) Either there are faults—this I have tried to show is all but impossible; or (2) there has been a landslip from a Chalk cliff overhanging a valley in the Kimmeridge Clay, and the Chalk once on Roslyn Hill has since been denuded away; or (3) the mass is an included Boulder, and has been brought to its present position on an ice raft. I think the facts accord best with this, and that there is no fourth hypothesis probable. The only point on which I differ from Mr. Fisher—and it is a very small one—is that I think the valley existed before the great boulder arrived, and was not ploughed out by the keel of its icy ship.

VII.—Account of an Expedition to Greenland in the year 1870.

By Prof. A. E. Nordenskiöld.

Foreign Correspondent Geol. Soc. Lond., etc., etc., etc.

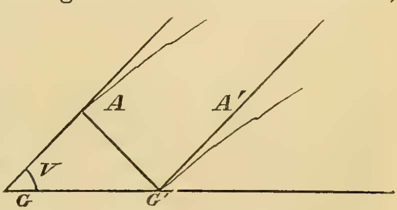
Part III.

(*Continued from page* 368.)

BEFORE proceeding to give an account of these changes in the fauna of Greenland, I wish to draw attention to the possibility which exists in these parts of obtaining a comparison between the units of geological and historical chronology, that is—if by collecting observations and reports from many different localities, it be possible to determine certain limits for the velocity with which the border of the inland ice moves. One may arrive at the lower limit from the following considerations. The breadth of the slip of border-land at Auleitsiviksfjord is about 60 miles, or 350,000 ft. The annual retreat can, of course, never exceed the thickness[1] of the covering that yearly melts, divided by the sine of the inclination of the icy surface, which in the places passed by us was nowhere less than 30°. It is hardly probable that during a summer in Greenland an ice-layer of more than 10 ft. can melt away, so that a yearly retreat exceeding $\frac{10}{\sin 30^\circ} = 20$ ft., is not to be thought of. This would give for the time that has been required for the uncovering of the outer strip of land at Auleitsviksfjord a period of at least 17,000 to 18,000 years. But this number is evidently too low, for neither the yearly falls of snow nor the advance of the ice-mass has been taken into account, as they of course ought to be; and yet we have here to do with a geological period, which undoubtedly forms but a small fraction of the interval that has elapsed since the first appearance of man.

The point at Sarpiursak forms a very level and extensive plain, elevated about 60 to 150 feet above the sea, covered with a vegetation of "lyng," moss and sedge, too scanty to conceal the clay which forms the bottom of the plain. Similar formations in many other places along the shores of Disko Bay and Auleitsiviksfjord have given rise to vast clay-beds, which attracted attention long ago in these parts so ill supplied with clay. Our Greenlanders even mentioned that they contained petrified shells and "Angmaksäter" (a species of fish). These fossils are also mentioned by Dr. Rink in his work on North Greenland; and he adds, that a collection which he had sent home had been examined by Dr. O. A. L. Mörch, who found the shells partly to belong to species still existing on the coasts of N. Greenland,

[1] Estimated at right angles to the surface of the ice. The annexed cut shows this more clearly. If G is the surface of the ice in *e.g.* 1870, G′ and the same surface in 1871, then AG′ is the thickness of the layer that has melted; and the distance the ice has receded is $= AG' : \sin V$. The angle V is, of course, determined by the relation between the velocity of melting and the velocity with which the ice flows out of the higher parts of the glacier.



partly to more southern forms. As the collection of materials for forming a judgment relative to the changes in the climate of the polar regions was one of the principal objects of the purely scientific part of our expedition, it was natural that we should pay especial attention to these circumstances.

Older glacial[1] fossils occur in N. Greenland in two different formations, namely, either imbedded in clay (the layers south of Waigat), or else at Pattorfik in a somewhat hardened basalt sand in course of transformation to basalt tufa. The material of the clay-beds has evidently been deposited by the glacier rivers whose muddy water everywhere bursts out from under the inland ice, but in general the deposits are sea-formations, *i.e.* they have been deposited under the level of the sea, which proves that these regions, in the course of the present glacial period, have been elevated at least 100 feet. The Danes, on the other hand, who have long resided in Greenland, declare most decidedly that a depression is now taking place in most parts of the country. Herr Einar Hansen, who has for 19 years lived in the colony of Omenak, says that even in that short period he has clearly seen this; and it is still more evident when we compare the present sea-level with the statements left by Herr Hansen's predecessor relative to its height 60 years ago. The situation of the blubber house at Fredrickshaab, as well as many other observations in South Greenland, shows the same. At Godhavn, in Disko, on the contrary, a rise is said to be taking place. It would be an important service if these circumstances, to which attention has been called by Pingel, Brown, and others, were fully investigated by an accurate and critical collection of all data relating to the subject; as also by fixing proper bench-marks in appropriate spots among the skerries along the coast of Greenland.

Just as the glacial clay at the present time, covered with muddy water, is poorly supplied with animal life, so also do these clay layers deposited in ancient times present but a scanty variety of fossils. In the clay-beds at Auleitsiviksfjord, for example, we could only find a few shells of *Saxicava arctica*, and in the deep clay-beds of Sarpiursak we at first sought in vain for any remains of animal life. These were, on the contrary, very numerous on the sea-shore itself, partly shells of bivalves still united, inclosing and often inclosed in a hardened mixture of sand and clay, accordingly genuine fossils, partly flat, often ringshaped claystones, containing remains of Fish, Ophiuræ, Crustaceæ, etc. That fossils should be found there in great numbers is easily understood, for the sea is constantly washing away again a clay bank of 60 feet high, and in this process of course larger

[1] Of course one finds in many places, at about the level of the sea, modern deposits, with sub-fossil shells, identical with forms now living. From these formations those of which we are now speaking differ, by the great age of these latter, and a very different type of the shell-remains found therein. This is especially the case with the shell-deposits at Pattorfik, which appear to me to belong to the earliest part of the glacial period of Greenland. A very considerable but lately formed bank of shell-earth, with bones of Whales and Walruses alternating with beds of sea-weed, occurs at Saitok, at the mouth of Disko-fjord. Unfortunately we had only time to investigate it cursorily.

objects (fossils and claystones) are left on the shore. But even here the fossils met with in the clay itself are but few. The claystones on the contrary form a separate layer, in which they are heaped close together. Similar fossils, together with a few Gasteropods, were collected by Dr. Öberg at the foot of a clay-bank, South Leerbugt, near Claushavn.

The fossils at Pattorfik were large and with thicker shells. They are found at a height of from 10 to 100 feet above the sea-level, imbedded in greyish green basalt sand, in part hardened into basalt tufa. This is especially the case in the neighbourhood of shells, and accordingly they were most easily discovered by breaking up the hard round nodules that are imbedded in the rest of the mass. These nodules are, however, often so hard and tough, that they cannot be broken up with an ordinary hand hammer. Besides these the basalt tufa contains large rolled blocks of stone, indicating that at the time of the formation of these layers, a glacial period had already prevailed in these regions.

The fossils[1] brought home by us from these parts have been examined by Professor S. Lovén, who gives the following list of them.

Subfossil Species of Animals collected in Greenland during the Expedition of 1870.

	Pattorfik	Sarpiursak	Leerbugt	Tessiur-sarsoak.
Mya truncata, L.	x	x	x	
Mya arenaria, L.	x	x	x	
**Cyrtodaria siligua*, Spgl.	x		x	
Saxicava arctica, L.	x		x	x
**S. Norvegica Spol.*	x			
Lyonsia arenosa, Möll.		x		
Tellina sabulosa, Spgl.	x	x	x	
T. tenua, Leach	x	x		
Astarte corrugata, Br.	x	x		
A. elliptica, Br.	x		x	
A. striata, Leach		x		
Cardium Islandicum, Chem. ...	x	x	x	
C. Grœnlandicum, Chem.	x	x	x	
Leda pernula, M.	x	x		
Yoldia truncata, Br.		x	x	
Y. hyperborea, Lovén.		x	x	
Mytilus edulis, L.	x			
Pecten Islandicus, L.	x			
Tritonium undulatum, Möll. ...			x	
T. Grönlandicum, Chem.			x	
T. hydrophanum, Hancock ...	x	x		
Natica clausa, Sow.		x		
Idothea Sabinei, Kröyer		x		

All species still living in the Arctic Seas. Those marked with * are called "fossil" by Dr. Rink—perhaps not found living in the Greenland waters.

After passing some time at Sarpiursak in collecting fossils, we removed to Christianshaab, and thence onward to Leerbugten,

[1] Krantz in his work speaks of fossil shells at Godthaab, *which are nowhere else found in these parts.*

south of Claushavn. By means of certain arrangements made by the Inspector, we were enabled to make a particularly interesting tour inland, to the extremity of one of the largest ice-fjords in Greenland—the ice-fjord of Jakobshavn.

This fjord is found inserted on very early maps of Greenland, though generally as a sound uniting the North Atlantic with Baffins Bay. It is now known that the supposed sound is only a deep fjord, filled throughout its whole length with huge icebergs, which completely close the fjord, not only to ships, but also to whale-boats and umiaks, nay, even to kajaks (canoes). The shores of the fjord are therefore uninhabited, and seldom visited. A tradition exists among the Greenlanders, that the fjord was in former times less obstructed by ice, and was consequently a good hunting and fishing place; and this is confirmed by the older maps of the fjord, but especially by the numerous remains of old dwellings, which are still met with along the shores, not only of the principal fjord, but of its southern arm, Tessiursak, now completely barricaded by icebergs and inaccessible from the sea (not to be confounded with the fjord Tessiursarsoak which we had just left). Tessiursak itself is still tolerably free from ice, and is easily reached by dragging an umiak over the point which separates the western shore of Tessiursak from the ocean. For such a purpose, however, a traveller must take his umiak with him, partly because he cannot obtain any boat at the now deserted Tessiursak. partly because about half-way over the point he meets with a lake, to go round which would be a considerable circuit.

On our arrival at Leerbugten, we found, in consequence of the Inspector's excellent arrangements, a Greenland family there to meet us, and the woman's boat, or "umiak," lay drawn up upon the shore. The journey over the point was immediately commenced. Six men took the roomy umiak upon their shoulders, others took our instruments, provisions for us and our people for two days. The way was taken first over a highland ridge, which separates the sea from the lake, on the shore of which the Greenlanders had pitched their summer tent. Here we rested awhile, and tried the temperature of the water (12° Centigr.), by a bathe in the lake, to the great astonishment of the Greenlanders. We then rowed over the lake in the umiak, took it up and carried it on our shoulders over another point, steeper but shorter than the former, and clothed just at this time in all the colours that the Flora of the extreme north can offer. On the other side of this point was water again, not however fresh, but salt—it was the above-mentioned southern arm of Jakobshavn ice-fjord. The umiak was again launched, and, after a row of a few hours, interrupted by hunting after young seagulls, we reached the spot where Tessiursak falls into the main ice-fjord very near its inner extremity. Here the water that was free, or nearly free from ice, terminated, and we had to make our way along the southern shore of the ice-fjord for a distance, not indeed long, but dangerous, on account of the masses of ice driven hither and thither by the violent currents near the shore.

Further out the fjord was completely covered with lofty sharp-pointed icebergs, some of which stood so firmly on the ground that the stream could only move them at flood-tide. Others, which did not draw so much water, were carried hither and thither by the currents, and it is difficult to describe in words the deep booming and scraping which took place when these were driven against each other or on the still mightier masses aground. A loud report sometimes gave notice of the splitting of an iceberg, which was usually followed by a violent undulation reaching to the shore. It is not surprising that the Greenlanders do not like to make long voyages in such waters. Neither did we long continue our row. Just on the other side of a headland formed by a high steep gull-hill, bordering the mouth of Tessiursak, were the remains of an old house, which formed the terminus of our journey. Here we rested for the night, and returned next day by the same route by which we had come. We employed our time partly in an examination from the tops of the neighbouring hills of the vast iceberg-factory that lay at our feet, and partly in a careful investigation of the remains of the dwellings left desolate for a century, perhaps many centuries, where we now rested.

I have already given a profile of the contour of this glacier, from which it may be seen that it is impossible to draw any definite line of boundary between the inland ice and the sea. The glacier is in fact, as its profile indicates, to a considerable distance up, probably several miles from its border, broken up into icebergs, the original situation of which has, by the continual advance of the ice, been entirely disturbed, so that they are thrown in confusion one over the other. Even at the mouth of the fjord these icebergs are as closely packed as when they formed a part of the glacier, and most of them perhaps always aground. It is not till a considerable distance further on that they are separated from each other, so far at least as to allow the surface of the water to be seen between them.

Even if there had been time to take topographical measurements, it would not have been possible for me to state how many hundred yards the situation of the house we now visited lies from the spot where the fjord and inland ice meet. What is certain is, that at present the distance is not very great, and the appearance of the environs must have been very different when Kaja—such is said in former times to have been the name of the locality—was an inhabited place. That it was so for a long period is shown by the magnitude of the kitchenmiddens, and by the number of remains of houses and of graves. Also either the level of the water in the fjord has risen or the land sunk considerably since that time. It is not in fact probable that the situation of a house would be chosen so close to the shore that not even a canoe could find room in front of the dwelling.

As a Greenlander now seldom resides at any distance from the Danish-trading stations, one finds in numberless places along the coast old deserted dwelling-places. They are recognizable at a distance by the lively verdure, arising from the rich vegetation, which the remnants of fishing and hunting prey scattered round the cottages or tents has produced. On taking a few spadefuls of earth, or on examining the walls of the new houses,—generally built with turf taken from these spots,—one everywhere finds the earth and grass-roots mixed with the bones of the animals which the Greenlanders hunt. The animals killed by the men are in fact cleansed by the women beside or in the cottage itself, and the refuse after the cleansing or the meal is thrown away—seldom far from the cottage-door. Even now, in the course of years, a heap is frequently collected as truly circular as if it had been drawn with a pair of compasses round the door as a centre. On examining its contents, it is found to consist of a black, fat earth, formed of decayed refuse—frequently bits of bone gnawed asunder and broken, shells, especially those of *Mytilus*, lost or broken household goods, etc. This bone-mixed earth most likely contains, like guano, not only considerable quantities of phosphoric acid, but also ammoniac salts, and it may happen that the trade of Greenland may find in this a valuable article of export.

As the kitchenmidden dates from the Stone-age in Greenland,—which undoubtedly extended beyond the epoch at which the whalers first began to visit these coasts,—we find in it points of arrows, skin-scrapers, and other instruments of various kinds in stone, and especially a mass of stone-flakes knocked off in forming the instruments, easily recognizable, not only by their form, but by their being of a species of stone—chalcedony, agate, and especially green jasper (called by the Greenlanders "angmak"), not met with in the gneiss formation, but only at certain spots in the basalt region of Disko or the peninsula of Noursoak. One sometimes finds smaller instruments of clear quartz, as also half-wrought crystals of the same mineral. Everything shows that the material was carefully chosen among such minerals as united the necessary hardness *with absence of cleavage, and a flat conchoidal fracture.* Among minerals in general, the different varieties of quartz (rock crystal, agate, chalcedony, flint, and jasper) are the only ones which fully satisfy these conditions; and it is therefore almost exclusively these minerals that the various races of men have chosen for making their *chipped* (not ground) stone instruments.

The two largest of the old house sites, among which we were now resting, lay so near the sea that their bases were washed by the water. A small stream had found its way through one of them, and had thus not only exposed a profile of the kitchenmidden, but also subjected a part of it to a washing process, in consequence of which bits of bone and other heavier objects lay clean washed at the bottom of the kennel and in the hollows of the gneiss slabs of the shore. These were carefully examined, and a number of stone instruments and stone chips were collected. There were no traces of iron, but a small piece of copper—an oval perforated piece—which had evidently once served as an ornament. At the largest site a tolerably thick round stone wall, 8 or 10 feet high, and 26 in section, was still distinguishable, divided into two unequal portions by a party-wall. The entrance seems to have led into the larger of these areas, judging from the extensive kitchenmidden situate just outside it.

In one of the other heaps of bones a flat stone was found, so large as to require the united efforts of several Greenlanders to turn it. They declared that the workshop for the fabrication of stone instruments must have been situated on that spot, and expected accordingly to find a great quantity of chips in its vicinity, which—however, the result of their searches did not confirm.

The kitchenmiddens outside the large cot rested on a low slab of gneiss, separated from it by a thin layer of turf, in which were no traces of any pieces of bone, and which had therefore been formed before the place was inhabited. In other respects this turf, of which specimens were taken away, was perfectly like the earth, which was mixed with bones and stone-chips. Here, there were no *Mytilus* shells, though these are everywhere else found around Greenland dwellings — an indication that the inhabitants were not formerly obliged to have recourse to the species of famine-food, whereof these bear witness.

To discover the various animal forms that had here been the prey of the hunter, Dr. Öberg collected a quantity of bones, in which work the Greenlanders took a lively interest, usually determining with great certainty the species to which the pieces of bone had belonged.

The following species could be ascertained:

Cervus tarandus.	*Phoca Grœnlandica.*
Ursus maritimus.	,, *hispida.*
Trichechus rosmarus.	,, *vitulina.*
Cystophora cristata.	*Delphinapterus leucas.*
Phoca barbata	

Even if we suppose that this spot was first inhabited shortly after the Esquimaux entered Greenland over Smith's Sound, its age will still be scarcely more than five hundred years, a period generally too short to show marks of the slow but continuous changes to which the organic world is subjected. Neither do the kitchenmiddens of Kaja contain any other forms of animals than those still living on the coast of Greenland. Nevertheless we obtain here an interesting confirmation of the changes that the ice-fjord has undergone. The Walrus, *Phoca barbata, Cystophora cristata,* no longer ventures into this long ice-blockaded fjord; and even the bear has now become so scarce, in the colonies of North Greenland south of the Waigat that most of the Danes resident in those parts have never seen it. The remnants of bones in the kitchenmiddens on the other hand prove that these animals were abundant there formerly, and are consequently an evidence that the fjord at Jakobshafn was less filled

[1] The views we got of the land inwards from a high mountain near Kaja showed, however, clearly, that the often repeated story of a strait passing completely across Greenland has arisen from a misunderstanding of the Greenlanders' accounts of the long narrow fjord. We received from the Greenlanders at Auleitsiviksfjord a similar account of the southern arm of that fjord; but on questioning them more closely, it appeared that they only meant that the distance to the extremity of the fjord was, according to their notions, immensely great. Krantz (in the middle of the last century) speaks of the fjord as quite full of ice. It was then so long before Giesecke's time, when, according to Brown, "this inlet was quite open for boats" (Quart. Journ. Geol. Soc., xxvii. p. 684.)

with ice than now. The uniform agreement of the older maps in placing here a strait, extending completely across Greenland, indicates that it is only within the last few centuries that this fjord has been converted into an ice-fjord, and that accordingly the same phenomenon, though on a larger scale, has taken place here as in the northern harbour of Belsound, Spitzbergen. Krantz mentions a similar case with reference to the ice-fjord north of Fredrickshaab, in South Greenland.

At all the old house-sites in Greenland one meets with graves, and such is the case here. The grave usually consists of a cairn, built of moderately sized stones, in the middle of which an oblong excavation, about the length of a man, and covered with a large flat stone, forms the chamber. In these we usually find the skeletons of several persons, so that the grave has been a sort of family tomb. Peculiar small chambers close beside the real grave-chamber form store-rooms for the deceased's outfit for the next world, We find here arrow-heads, scraps of leather, bone, stone or iron knives, water-ladles, bits of stone pans, lamps, pieces of flint, bows, models of canoes, oblong smoked pieces of pebble-stones, small wooden staves, according to the statement of the Greenlanders, dipped in oil, and to be used as torches, etc., etc. In a similar grave-chamber at Fortune Bay I found a number of glass beads, evidently of European origin, beads of bone, flint-points, and some rusty nails (these last probably the most costly among the valuables, which the male or female potentate resting in the grave was to take with him or her to the other world). A Greenlander gave to Dr. Öberg a pair of blinkers, or, more intelligibly speaking, snow-spectacles, made of wood, found in a grave. The proprietor would seem to have suffered from weak eyes, and to have been afraid of the reflexion of the light from the snow-fields in the abode of the blessed.

It seems to be usually assumed, that whatever iron is met with among the Greenlanders is either of meteoric origin, or else has come from the original Northmen colonists, or from the Greenland merchants and whalers of modern times. This assumption appears to me erroneous. First, as regards meteoric iron, it is certainly met with in Greenland, as in all other lands that have been but a short time inhabited by man; in other countries it has been used up during the period when iron was more valuable than gold. The meteoric iron that has hitherto been found in Greenland is, however, generally too hot-short, cold-short, and brittle, to be otherwise than exceptionally used; and even if a piece of better quality should be met with, I cannot see how the Greenlanders, with the tools they at present possess, could possibly forge an arrow-point out of a piece of iron weighing a couple of pounds. But, on the other hand, since the time when ships first began to cross the Atlantic, a wreck may now and then have been carried by the current on to the coast of Greenland, sometimes far up Baffin's Bay. We were able to verify an example of this. In fact, during our stay in North Greenland, a fragment of a small schooner or brig drove on shore at Disko, between Diskofjord and Mellanfjord. As soon as notice of the matter was given, the Greenlanders in the neighbourhood made an accurate inventory of everything on board that could be turned to any useful purpose. They found bread and sundry other provisions, also potatoes, but no paper or any indication of the name the ship had once borne, or the nation to which it had belonged, further than that the brass bolts by which the timbers were fastened together bore the stamp "Skultuna;" they were therefore from the Swedish brass-foundry of that name, and it is perhaps probable that the vessel itself was either Swedish or Norwegian. It was a two-masted vessel of 100–150 tons burden, according to the estimate of the Danes, and, according to the Greenlanders, could take a cargo equal to about half that of a three-master. The timbers were of oak, the outer covering of pine, the sides were not strengthened to resist ice, the stern was round "as a Dutchman's." The Greenlanders asserted that undoubtedly the ship was neither a whaler nor intended to sail amongst ice—and there is not the slightest reason to doubt the accuracy of their judgment, which is most sagacious in such matters. We have then here an example of a wreck drifting hither from the southern seas. Similar events must of course have often happened before, and what an abundance of iron the wreck of a ship supplies to a Greenland colony with its limited wants, is evident from the quantity of iron lying, at our visit, scattered around the houses in Godhavn, and obtained from whalers that had been stranded there in the preceding year. Here again was evidence of the Greenlander's improvident character. It never entered the mind of any one of them, out of all that quantity of iron—sufficient perhaps to supply the wants of the Greenlanders for a century—to preserve more than what he for the moment required; and if the regular exportations from Europe were to cease, the colony would again in a few years have to go back to the bone-knife, the bow and the flint implements.

For bone-knives, such as are sometimes found in old graves, the edge of which is formed by an iron plate let into a groove in the bone, a piece of an iron hoop of a barrel, that may have washed ashore, may easily enough have been used; an old worn-out iron knife would have been less fit for the purpose. These iron-shod bone-knives are therefore by no means always remnants from the time when the iron brought into the country by the Northmen in the beginning of the present millennium had begun to be scarce, but merely examples of the Greenlanders' way of turning to use for their simple wants, in the most appropriate manner, any objects that may come in their way.

At Kaja persons have been buried, not only in ordinary graves, but in low caves formed at the foot of neighbouring steep cliffs of gneiss by huge blocks of rock fallen from the mountain one over another. Most graves in the vicinity of the colonies have been long ago plundered by searchers after antiquities. This was not the case in this distant locality; nevertheless, all that we found in the graves was a pair of water-ladles and arrow-heads. On the other hand, as has been already said, a rich harvest was gathered at the sites of the old houses.[1] Some skulls were also taken, the Greenlanders not appearing to object to this; and as it is a matter of the greatest scientific interest to obtain perfectly authentic skulls of the original inhabitants of Greenland before any mixture of race had taken place.

On the 31st of July we returned to Leerbugten, where we were obliged to divide our little expedition into two parties. It was of interest to the geologists to visit as many places along the coast as possible, even if it were only for a few hours, whereas the botanist and the zoologist for their researches, and especially for the preservation of their collections, were obliged to remain at least some days at each place. Dr. Berggren and Dr. Öberg therefore now went together, to collect from the bottom and from the mountainous shores of Disko Bay materials for the fauna and flora of the place. Dr. Nordström and I, on the other hand, hastened to the Basalt region, to seek for new sources of the climatological history of the extreme north in the coal, sand, and clay-beds to be met with there. The harvest we gathered was rich beyond our expectations.

In the first volume of his work on Greenland, Krantz has introduced some notices of the mineralogy of the country, whence we find that the coal-beds of Disko were then (1765) already known. A statement of the Greenlanders is moreover adduced, that in certain distant parts all sorts of fishes were to be found turned into stone. Some years later the surgeon Brasen, who in 1767 made a voyage to these parts for his health, collected a quantity of minerals, of which a catalogue is given in the third volume of Krantz's work. This catalogue contains twenty-five items, including different varieties of quartz, granite, graphite, pot-stone (steatite), pumice-stone (of which it is justly remarked, that it has been brought hither by the currents from Iceland), and so forth. In the beginning of the next century (1806-1813) C. Giesecke—who was first an actor, afterwards a mineralogist with the title of "bergsraad," and lastly professor in Dublin—and Knight made extensive mineralogical excursions on the coasts of Greenland. Giesecke himself has published but little of his observations,[2] though carefully kept journals of his travels are preserved in manuscript at Copenhagen. Numerous and important new discoveries prove that his researches were carried out in a true scientific spirit, and with a completeness and accuracy the like of which but few of the old civilized lands of Europe could at that time produce. Even North Greenland was visited by Giesecke. Here he discovered, among other things, plant-fossils at Kome[3] and at the east coast of Disko,[4] and furnished several instructive sections.

[1] Stone implements of various kinds were collected and purchased by us at several other places, so that the collection we brought home consisted of above 1000 specimens. Dr. Öberg made the richest harvest at Kikertak.

[2] In Brewster's Edinburgh Encyclopædia, vol. x., pp. 481–502, under the word "Greenland," is an article written by Giesecke, containing, among other things, some short notices of the mineralogy of that country. There is also a work by him on Cryolite in Edinburgh Philo. Journal, vi., 1822.

[3] Giesecke's Journal. Heer's Flora Fossilis Arctica, p. 7.

[4] The above-mentioned article in Brewster's Edinburgh Encyclopædia, p. 493.

Subsequently (1838) the coal-beds of North Greenland were, by order of the Danish Government, examined by J. C. Schythe, though, as it appears, chiefly for technical purposes. A more important event for geological science was Dr. Rink's four years' residence (1848–1851) in North Greenland, during which time he visited many parts of the Basalt region, whence rich collections were taken home, among which may be mentioned fossil trunks of trees from several places, as also the fossils from Kome described in Heer's Flora Fossilis Arctica. Some years later a Dane, Jens Nielsen, residing at Atanekerdluk, discovered magnificent Miocene fossils there, a large number of which were collected, when Captain Inglefield, in company with Captain Colomb, and Obrik, the Inspector of North Greenland, visited the place in July, 1854.

These strong proofs of a climate formerly warm, up in the neighbourhood of the Pole, aroused wonder and astonishment in all who saw them. More collections were made, partly by Inspector Obrik,[1] partly by other officials of the Danish Trade. Also Prof. Torell, Dr. Walker, Dr. Lyall, and others brought home not inconsiderable collections from their travels in Greenland.

The importance of this discovery to the history of our globe was, however, first taught by means of Heer's Flora Fossilis Arctica, in which these fossils are described, together with similar fossils collected during the English Franklin Expeditions from the most northerly archipelago of America, by Prof. Steenstrup from Iceland, and by the Swedish Polar Expeditions from Spitzbergen. The British Association had already (1867), at the instance of Mr. Robert H. Scott, F.R.S., sent out an expedition to make new researches in this geologically interesting quarter. These were entrusted to Messrs. Whymper and Brown;[2] but in consequence of a combination of unfavourable circumstances, the new researches were confined to the already well-examined locality of Atanekerdluk and the opposite shore of the Waigat. The new collections thus indeed completed the knowledge we already possessed of the Flora of the Miocene Period in the extreme north, but they opened no new views of the periods which immediately preceded and followed it.

As in 1858, and especially in the Spitzbergen expedition of 1868, I had had the opportunity of contributing in some measure to the climatic history of the extreme north, this question interested me in

[1] Mr. Obrik's collections were given partly to the University Museum at Copenhagen, partly to Capt. M'Clintock, who, on his return in 1859, passed Disko, and, on returning home, presented them to the Royal Society in Dublin, the same institution to which Capt. Colomb had presented his collections. Capt. Inglefield's collections were given partly to the Geological Survey in London; Dr. Walker's and Dr. Lyall's (from the eastern side of Disko, near the surface of the sea) to the Botanical Museum at Kew; Prof. Torell's to the National Museum at Stockholm; Mr. Whymper's and Mr. Brown's to the British Museum. The collections from Spitzbergen and of the expedition of 1870 will be divided between the Museums of Stockholm and Gottenburg.

[2] On this journey, see Osw. Heer, "Contributions to the Fossil Flora of North Greenland, being a Description of the Plants Collected by Mr. Edward Whymper during the Summer of 1867."—Phil. Transactions of Roy. Soc., vol. 159, part ii., p. 445. 1870.

the highest degree. It was especially desirable to collect materials from the Cretaceous beds at Kome, and to obtain, if possible, plant-fossils from the long periods intervening between the fern-forests of the Cretaceous and the beech and plane woods of the Miocene Epoch; as well from the ages intervening between the last-mentioned era and the present time. This was the object of Dr. Nordström's and my tours during the remainder of the summer.

Aug. 1. We departed in the Inspector's yacht, with our own whale-boat in tow, from Sandbugten to Flakkerhook, where the Inspector took leave of us, promising to meet us again at Atanekerdluk. We rowed, touching at a number of intermediate places to collect plant-fossils, past Mudderbugten, round Isungoak, to Ujarasusuk, whence I passed, in a boat obtained from the Danish officer, to Ritenbenk coal-mine, north of Kudliset, and then crossed the Waigat to Atanekerdluk. Dr. Nordström stopped a little longer to collect more fossils at Ujarasusuk, and thence sailed in somewhat rough weather direct to our appointed place of meeting. On this now uninhabited spot we all met on the 5th of August. On the 9th we rowed farther, to Mannik, Atane, Noursak, and Noursoak, where we remained a couple of days (August 12 and 13).

The time was employed partly by a visit to the coal-beds of Netluarsak, situated high up in the basalt beds between the two last-mentioned places. From Noursoak the Inspector continued his journey to Upernivik, while we rowed along the shore of Omenak-fjord, touching at Niakornet, Ekkorfat, Karsok and other places, to Pattorfik. From Niakornet and Karsok two trips were made into the interior, to coal-beds at Ifsorisok and to the famous graphite-bed at Karsok. From Pattorfik we rowed over the fjord, though densely packed with icebergs, to Omenak, where we arrived on the 20th of August. Here we were detained by the ice a couple of days, during which we were lodged in the most hospitable manner by the local Colonial Governor, Mr. Boye.

On the 22nd, in the afternoon, we rowed over to Assakak glacier, and the following day onward to Kome, whence we went on board a ship lying there belonging to the Greenland Trade, in which, in the evening of the 24th, we set sail for Godhavn, where we arrived on the 30th, and whence some excursions were made to the spot where the meteoric iron was discovered at Ovifak; to Saitok, at the mouth of the Disko fjord; to Puilasok, and Sinnifik. Shortly after our arrival at the last-mentioned place (Sept. 3), we received a Kayak express from Godhavn with the news that war had broken out, which induced us to hasten back to the colony in order to avail ourselves of the first opportunity to return to Europe. As no vessel was just then lying there, nor was any expected to arrive at Godhavn for the next few days, I immediately passed over to Egedesminde. Dr. Nordström remained at Godhavn, awaiting Drs. Öberg and Berggren, to return home with them. At Egedesminde I went on board the brig Thialfe, commanded by Captain Brockdorff. Contrary winds prevented our departure till the 23rd of September, and the passage was slow in consequence of storm and unfavourable winds, so that it was not till the 2nd of November that I could land at Elsinore.

During the whole period of our boat excursions in Greenland we had, with the exception of one rainy night, a constantly clear sky and a favourable sailing breeze: circumstances which greatly facilitated our movements, and rendered it possible in so short a time to investigate at least the principal geological features of that remarkable tract, and to collect extensive series of plant-fossils from above twenty separate localities and belonging to five widely-separated geological horizons.

Like previous similar collections from the Arctic regions, these have been transmitted for examination to Prof. Osw. Heer, of Zurich, and I venture to hope that, when duly interpreted, they will give us an idea of the changes of climate these regions have undergone since the epoch when serious variations of climate first took place upon the globe. I will only offer a few short remarks on the geognosy of these interesting beds.

Greenland basalt or, as it is also called, trap-formation, probably extends completely across the country north of the 69th degree of latitude; at least Scoresby found, in his remarkable visit to the eastern coast of Greenland, trap with the impression of plants[1] at many places along the extent of coast visited by him. It is possible that the same formation may continue under the sea to Iceland, and thence, partly in a more northerly direction over Jan Mayen to Spitzbergen, partly in a southern direction from Jan Mayen, over the Faroe Islands, to the Hebrides and Ireland.[2] The same eruptive formation extends also westward over a vast part of Franklin's Archipelago, perhaps even to the volcanic tracts at Behrings Sound. These basalt beds probably all arise from a volcanic chain, active during the Tertiary Period, which perhaps indicates the limits of the ancient polar continent, in the same manner as is now the case with the eastern coast of Asia and the western of America, thus confirming the division of land and water in the Tertiary Period, which upon totally different grounds has been supposed to have existed.

This formation appears most developed in North Greenland on the large Island of Disko, as also on the peninsulas of Noursoak and Sortenhook, where it occupies an area of above 7000 square miles with a vertical section of 3000 to 6000 feet.

Even here these eruptive rocks are divided into beds which, between Godhavn and Fortune Bay, rest immediately upon the gneiss formation; on the strand of Omenakfjord, between Ekkorfat and Kome, upon sand and clay beds belonging to the Cretaceous age. To the east of Godhavn, again, at Puilasok and Sinnifik, we meet with sand and clay beds lying between, not under, the basalt

[1] Scoresby's collections from these parts seem to have been lost. On the other hand the last German expedition to East Greenland brought back collections of plant impressions which have also been placed for investigation in the hands of Prof. Osw. Heer.

[2] The agreement between the basalt formations of Greenland and the British Islands, both as regards the character of the rocks and the age of the beds, seems to be perfect.

rocks, and accordingly newer than these latter. Also the fossils in these beds belong to the Tertiary Period. It follows then, *that the eruptions, which have given rise to these vast beds of basalt, have taken place subsequently to the commencement of the Cretaceous, and have ceased before the termination of the Tertiary Period.*

In the preceding pages I have intentionally spoken of basalt strata and schists. In almost every place where I have had the opportunity of examining it, the Greenland basalt is so stratified that one is forced to admit, that it is only exceptionally that we have to do with consolidated masses of lava, but for the most part with eruptive sedimentary beds of volcanic ashes and volcanic sand, which in the course of thousands of years have become hard again and assumed a crystalline structure.

Any clearly decided lava-streams I have scarce had occasion to observe, even larger or smaller dykes are not so common as one might expect, and where they are found the mass of lava ejected has scarcely produced any effect upon the loose beds of sand, clay, or basalt that it has pierced.

No volcanoes, either extinct or active, are met with in these parts, although circular depressions in the basalt plateau, caused by glaciers or brooks, may, when carelessly observed, easily be mistaken for true craters. It is, of course, quite natural that great cavities in the interior of the earth must arise in the places whence the great eruptions have issued, which have produced the basalt region of Greenland, and that these in their turn must, within a short period, be followed by the destruction of the superjacent volcanic cone. The place or places where these old volcanoes once rose high over the surrounding plains will therefore now most probably correspond to the greatest depths in the neighbouring sea.

At Godhavn the lowest strata resting immediately upon the gneiss formation (*e.g.* outside Bläsedalen) consist of a basalt tuff or breccia containing various species of zeolites (according to Giesecke, only apophyllite), next comes columnar basalt, free from zeolites, then again basalt tuff with zeolites, alternating with true basalt. A coarse crystalline dolerite, very similar to the Spitzbergen hyperite, forms at Atanekerdluk, near the shore, a hill several thousand feet high.

The basalt beds are 50 to 100 feet thick, and may be traced for miles along the shores, often separated from each other by thin layers of red basaltic clay. Sometimes the layers are crossed by dykes of a hard, fine-grained basalt.

Not only dykes, but also basalt beds have, on the cooling of the melted mass, or during the drying and crystallizing process which the volcanic ashes have undergone in their transformation to basalt, been broken into regular columns, mostly hexagonal. Brännvinshamn, Skarffjäll, Kudliset, and other places on Disko and the peninsula of Noursoak, afford examples of this kind of basaltic structure, comparable in magnificence with Staffa and other geologically famous European localities.

Volcanic eruptions, as has been above remarked, no longer occur in this region. Yet, in consequence of the rapidity with which basalt is destroyed, layers of basalt sand constantly collect on the shores—beds which, in the course of thousands of years, may, under favourable circumstances, harden to a rock not distinguishable from real basalt, unless perhaps it be by the circumstance, that as these beds are deposited in the sea, they may possibly contain marine fossils, which the tuffs of pure basalt formations do not. Such a hardened fossiliferous basalt sand occurs at Pattorfik, in Omenak-fjord and between that place and Sarfarfik. This stratum, which has already been described, is, however, evidently far more recent than the newest beds of the real basalt.

Young as the colonies in these parts as yet are, tradition can nevertheless adduce sundry examples of the rapidity with which basalt rocks are destroyed. It is difficult to induce a Greenlander to penetrate by boat into the inner parts of the three fjords which cut into the west coast of Disko Island. The reason of this is said to be, that on one occasion a whole house with all its inhabitants was crushed by a sudden fall of a basalt rock. At Godhavn, on the brow of the basalt mountain, there were formerly twelve huge projecting elevations, called the twelve apostles. Of these there is now but one remaining.

In the immediate neighbourhood of Godhavn the basalt either extends completely down to the sea or lies immediately upon the gneiss formation, which there occupies the strand-cliffs. On rowing from this point further to the east, as soon as one is past Skarffjället,[1] sand or sandstone beds are found nearest the shore, increasing in thickness as one approaches the Waigat, so that at Flakkerhook and Isungoak they form mountains of 1500 to 2000 feet high, frequently crowned with a perpendicular basalt diadem. The same formation is met with on the other side of the Waigat at Atanekerdluk. Further north-west in the strait, however, the conformably stratified sand and basalt beds sink again, so that before one arrives at Noursak the basalt reaches the sea-level. Beyond that point the peninsula is entirely occupied by basalt-beds, terminating in terraces, between which no sand-layers can be discovered from the shore. But at a height of from 1000 to 2000 feet above the sea we find here, also, purely sedimentary formations of sand, clay, coal, etc., but very thin, and therefore, for the most part, concealed by basalt detritus.

Further inward, the shore of Omenakfjord is occupied exclusively by basalt, extending beyond Niakornet; but afterwards we again meet with a formation similar to that of Atanekerdluk, though of a widely different age, and resting, not upon basalt, but upon gneiss. These layers belong to the lower Cretaceous. Here the basalt strata no longer extend down to the water, and the shore pebbles farther inward are again of gneiss. But the glaciers that extend downwards from the interior continually carry with them basalt blocks and basalt columns, indicating that the lofty inland mountains are still

[1] Some of these beds (at Puilasok and Sinnifik) nearest Godhavn are however more recent than the basalt formation, i.e. stratified *between*, not *under*, the rock of the basalt formation.

composed of that rock; and that there also it is interstratified with Tertiary schists is evidenced by the plant-remains that, on the Assakak glacier, lie mixed with pieces of basalt on the surface of the ice.

Here also was found a piece of basalt with wood immediately inclosed in the basalt; but, with this one exception, all the fossils have been found in the Coal-bearing sand and clay beds which accompany the basalt, and in Greenland are met with only in the basalt regions. I have, however, no doubt that organic remains will be found in the red basalt clay that lies between the real basalt beds, though we had not time to look for them.

The fossils in the sedimentary strata of the trap-formation[1] in Greenland consist exclusively of plant-remains, and fragments of one or two insects and fresh-water mollusca; there are no traces of marine mollusca nor vertebrate animals. An extensive continent, then, occupied this portion of the globe at the time when these strata were deposited; and the abundance of the sand strata, furthermore, seems to indicate that, during the Cretaceous and Tertiary Periods, this was a vast sandy desert, varied only by oases of inconsiderable extent. *At that time there were no glaciers in these parts.* For the sand strata contain no traces of any such erratic blocks or large boulders as always accompany and characterize the Glacial formations, and which are met with even in loose clay-beds of Glacial origin, which, where a subsequent denudation has taken place, cover the beds of basalt and Tertiary sand. I ought however to mention that in places where both the modern Glacial formation and a part of the subjacent Tertiary sand have been washed away, sections often occur, which, on a cursory examination, seem to indicate that the Tertiary sand contains a vast quantity of erratic granite and gneiss blocks. But wherever time permitted us to make a careful investigation, or where, as is the case in most of the places

Fig. 7.

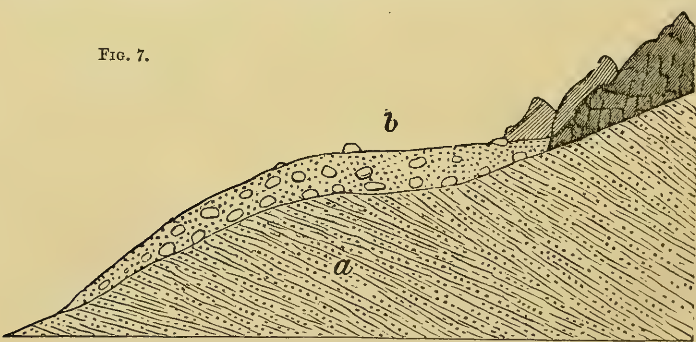


Fig. 7.—*Section before any modern denudation had taken place.*
(*a*) Tertiary strata without erratic blocks. (*b*) Glacial strata with erratic blocks.

[1] I have preserved this name as used in Greenland as a common denomination for the Cretaceous formation, dolerite, diabase, basalt, the Tertiary strata included in basalt, as also the strata at Sinnifik and Puilasok, probably deposited shortly after the cessation of the eruption of the basalt.

where plant-remains are found, fresh perpendicular sections are exposed, it has become evident that these blocks have been washed down from superjacent more recent Glacial strata (*b*), and in no wise belonged originally to the Tertiary strata (*a*), in which they now lie. The accompanying figures show this clearly :—

FIG. 8.

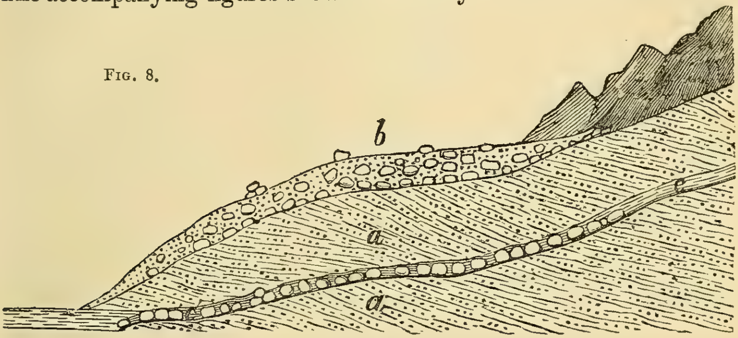


FIG. 8.—Section along a modern mountain-stream (*c*—*c'*).

These Tertiary beds therefore do not afford any evidence that the favourable climatic circumstances of the Tertiary era have been interrupted by a separate Glacial period, which has subsequently disappeared. The Cretaceous, Miocene, and recent sand-beds are in outward appearance perfectly alike, and if a new elevation should expose the sand-beds now in process of formation in many places at the bottom of the Waigat, these, wherever they were destitute of organic remains, would be very difficult to distinguish from the Cretaceous sandbeds at Kome, or the Miocene beds at Atanekerdluk, Isungoak, etc.

It was formerly supposed that the whole Coal-formation of Greenland belongs to the same geological period. Heer's important discovery, that the beds at Kome and Atanekerdluk belong to two widely different periods, showed that this is not the case. Subsequently a stone was found in Disko containing an impression of a real *Sigillaria*. This stone, however, appears either to have been brought hither as ballast or by ice. At least, we could not anywhere in these parts discover beds belonging to the old Carboniferous Period.[1] The discovery of Heer was not only confirmed by our researches last summer, but we also discovered plant-remains from one or two geological horizons quite new for N.W. Greenland.

In the description of these I follow the chronological order, beginning with the oldest.

I.—*The Kome strata* (older division of the Cretaceous formation, according to Heer).

By this name I designate a sedimentary, coal-bearing formation, occurring here and there between Kome and Ekkorfat, on the line of the coast of Noursoak peninsula, situated S.W. of Omenak. The

[1] Fossils really belonging to the Coal period have since (Expedition of 1871) been found by Dr. Nauckhoff, at Kudliset.

name is taken from the place where the chief coal-bed is found, and from which, in all probability, the plant impressions came, which were brought thence by Giesecke and Rink. These strata, however, occur not only at Kome, but all along the above-mentioned coast, with the exception of a few interruptions by gneiss hills. The Kome strata, as the accompanying section shows, rest immediately upon undulating gneiss-beds, probably filling up old valleys and depressions between them. Higher up the gneiss is covered by eruptive rock. The strata generally lie tolerably horizontal, sometimes even with a dip inwards of as much as 20° towards the peninsula of Noursoak. They are most developed in the neighbourhood of the two extremities, Ekkorfat and Kome, where the thickness exceeds a thousand feet.

As the plant fossils occur almost exclusively in the lowest strata, we cannot, without a careful examination of the few fossils we have brought home from the upper strata, decide whether the whole of this vast series of strata belong to the same geological formation or not. It is, however, probable the upper portion, distinguished by its thick coal-bed, belongs to the next division.

Most part of the Kome strata consists of sand or a loose sandstone, often, however, interstratified with beds of slate and bands of coal. The slate is generally mixed with sand, and, as it were, thoroughly corroded by acids, and in these cases so loose that the plant fossils it may perhaps contain can scarcely be preserved. Fortunately there is also found, especially in the neighbourhood of the lowest coal-beds, a harder, sometimes argillaceous, sometimes talcose, slate with numerous impressions, chiefly of ferns and Coniferæ (not only twigs, but cones, seeds, and leaves). The leaves especially occur in abundance, generally transformed into a dark brown, semitransparent, parchment-like mass, resembling the vegetable parchment which is produced by the action of sulphuric acid on lignite. Some beds occur in which these leaves are so numerous that the beds form a felt, which is flexible, and can almost be ravelled, woven of leaves and other similarly transformed remnants of plants. It is possible that this fossilization depends upon the action of the acid gases which have come forth during the volcanic eruptions and condensed themselves in the waters of the locality, and thus that the condition of the fossil leaves is connected with the extremely corroded appearance of the slate and sandstone.

The most important of the coal-beds[1] occur in the upper part of the strata at Kome, but bands of coal are interstratified with the slate in many other places, but they are not very extensive, though sufficient to provide a few Greenland households with the few tons of coal they want in the year. At present, according to the statement of the Governor of the colony, coal is thus collected, not only at Kome, but also at Sarfarfik, Pattorfik, Avkrusak, and, though less frequently, at Ekkorfat.

To this, or rather to a still more recent formation, belongs also

[1] As stated above, the coal-beds probably do not belong to the *under*, but to the *upper* Cretaceous (the Atane beds).

the remarkable layer of graphite at Karsok, and probably also the layer of graphite at Niakornet. One has to pass over a tolerably extensive subjacent band of gneiss before arriving at the sedimentary strata, which appear, with a steep inclination, on the bank of the Karsok river at a height of 840 feet. Afterwards, slopes of basalt, boulders, gravel washed down from the mountains, etc., continue, till, at a height of 1150 feet, one arrives at a terrace covered with gravel, in which a few angular fragments of graphite may be discovered, as also angular fragments of a hard sandstone impregnated with coal. In consequence of the unfitness of our Greenland assistants for real labour, our attempts to dig through the strata of gravel, and reach the graphite bed, were unsuccessful; but we were informed by Capt. G. N. Brockdorff—master of the ship which, in 1850, was to have taken out a cargo of graphite to Europe, and which actually carried over about five tons of that mineral—that the graphite here forms a horizontal bed eight to ten inches thick, covered with clay, sand, and angular fragments of sandstone. This interesting graphite bed does not contain any organic remains; but as both the underlying Cretaceous strata and those of graphite lie horizontally and in the neighbourhood of each other, and the latter is situated about 300 feet higher up, it is evident that *the graphite at Karsok belongs either to the Cretaceous or to a still later period.*

(*To be continued in our next.*)

NOTICES OF MEMOIRS.

I.—On the Occurrence of the "Chalk Rock" near Salisbury. By William Whitaker, B.A. (Lond.), F.G.S., of the Geological Survey of England.

[From the Magazine of the Wiltshire Archæological and Natural History Society, vol. xiii., 1871, p. 92.]

IN 1861 a bed was described, under the name "Chalk-rock," which, in the counties of Wilts, Berks, Bucks, Oxon, and Herts, seemed to form the top of the Lower Chalk.[1] Its occurrence in the Isle of Wight, though in a less marked form, has since been noticed;[2] some new sections in North Wilts have been described in the Wiltshire Society's Magazine by my friend Mr. T. Codrington,[3] and I have also seen it in Bedfordshire[4] and Dorsetshire. As it is open to view near the town (Wilton) where the Society is to hold its meeting this year (1870), a description of two sections in that neighbourhood may perhaps be acceptable.

The Chalk-rock, where best developed (from near Marlborough to near Henley-on-Thames), is a hard somewhat crystalline cream-

[1] Quart. Journ. Geol. Soc., vol. xvii., p. 166. See also Geological Survey Memoirs on Sheet 13, p. 19 (1861), and on Sheet 7, p. 5 (1864).
[2] Quart. Journ. Geol. Soc., vol. xxi., p. 400. [3] Vol. ix., p. 167.
[4] Mr. J. Saunders, whose notice I called to this bed, has described a section near Luton, Geol. Mag., Vol. IV., p. 154.

coloured chalk, ringing when struck with the hammer, jointed, and with layers of irregular-shaped green-coated nodules. Sometimes, however, it consists simply of one hard nodular layer.

In the cutting on the South-Western Railway just north-east of Barford St. Mary (west of Salisbury), there is a good thickness of the Upper (or flinty) Chalk, the flint occurring both in the form of nodules and of thin tabular layers. From below this the Lower-Chalk (which here contains a few flints) rises westward at a very small angle; it is hard and of a somewhat nodular structure, and at (or close to) the top has a layer of green-coated nodules. This hard nodular layer is the bed to which I wish to draw attention, not only on account of its wide range and distinct character, but also because it yields a somewhat peculiar set of fossils.

A better section is given by a smaller cutting close by westward, where the chalk-rock (dipping 2° or 3° eastward) forms a hard ledge a foot or more thick, with green-coated nodules at its well-marked top, sharply dividing it from the chalk above, whilst on the other hand it passes down into nodular chalk, both hard and soft, in which another but fainter bed of the "rock" occurs about five feet below the layer of nodules. There are flints in the Upper-Chalk, and thin layers of marl in the Lower.

As these sections are very near the outcrop of the Upper Greensand, it follows that the Lower Chalk and the Chalk Marl are comparatively thin here.[1]

II.—Forty-second Meeting of the British Association for the Advancement of Science. Brighton, August 14th to 21st, 1872. Papers Read before Section C. (Geology.)

R. A. C. Godwin-Austen, Esq., F.R.S., *President.*

Address by the President, R. A. C. Godwin-Austen, F.R.S.

Prof. E. Hull, F.R.S.—On the Raised Beach of the North-East of Ireland.

Jas. Howell—On the Supra-Cretaceous Formation in the Neighbourhood of Brighton.

W. Topley, F.G.S.—On the Sub-Wealden Exploration.

G. A. Lebour, F.G.S.—On the Geological Distribution of Goitre in England.

W. Pengelly, F.R.S.—Eighth Report of the Committee for the Exploration of Kent's Cavern, Torquay.

W. Pengelly, F.R.S.—Notes on *Machairodus latidens* found in Kent's Cavern, Torquay.

W. B. Carpenter, M.D., V.P.R.S.—On the Temperature and other Physical Conditions of Inland Seas, considered in reference to Geology.

Henry Hicks, F.G.S.—On the Cambrian and Silurian Rocks of Ramsey Island, St. David's.

[1] A very good example of the "Chalk Rock" may be seen on the top of Whitesheet Hill, South Wilts. It is there about three feet in thickness.—W. Cunnington.

J. Hopkinson—On the Occurrence of a remarkable Group of Graptolites in the Arenig Rocks, St. David's.

H. G. Seeley, F.G.S.—On the Occurrence of a British Fossil *Zeuglodon* at Barton, Hants.

Prof. E. Hébert—Sur les divisions de la Craie en France, leurs limites et leur faune, l'identité de ces divisions des cotés du détroit.

James Thomson, F.G.S.—Fourth Report of the Committee for the Continued Investigation of Mountain Limestone Corals.

James Bryce, LL.D., F.G.S.—Report on Earthquakes in Scotland.

William Jolly—Report on the Discovery of Fossils in certain remote parts of the N.W. Highlands.

Prof. H. Alleyne Nicholson, M.D., F.R.S.E.—On the Geology of Thunder Bay and Shabendowan Mining Districts on the North Shore of Lake Superior.

Prof. H. A. Nicholson—On *Ortonia*, a new genus of Fossil Tubicolar Annelides, with Notes on the Genus *Tentaculites*.

Rev. Canon Tristram, F.R.S.—On the Geology of Moab.

Prof. Edward Hull, F.R.S.—On the Trachyte Porphyry of Antrim and Down, Ireland.

Prof. James Hall—Note on the Occurrence of Erect Bases or Trunks of *Psaronius* in the Devonian Rocks of New York, U.S.A.

W. Carruthers, F.R.S.—On the Tree Ferns of the Coal Measures and their Affinities with Existing Forms.

Prof. Albert Gaudry—Sur les Animaux Fossiles du Mont Leberon.

Prof. James Hall—On the Geographical Distribution of the Middle and Upper Silurian (Clinton, Niagara, and Upper Helderberg) Formations in the United States.

Thomas Davidson, F.R.S.—Brief Notice of the Present State of our Knowledge in Connexion with the Brachiopoda.

Henry Woodward, F.G.S., F.Z.S.—Sixth Report on Fossil Crustacea.

Rev. John Gunn—On the Prospect of Finding Productive Coal Measures in Norfolk and Suffolk, with Suggestions as to the Places best adapted for an Experimental Boring.

Thomas Davidson, F.R.S., and *Prof. William King, D.Sc.*—Remarks on the Genera *Trimerella, Dinobolus*, and *Monomerella*.

G. vom Rath—On a Remarkable Block of Lava, ejected by Vesuvius during the Great Eruption of April, 1872, Proving the Formation of Silicates by Sublimation.

J. Gwyn Jeffreys, F.R.S.—A Few Remarks on Submarine Explorations, with References to M. Delesse's Work, "Lithologie du Fond des Mers."

Dr. Leith Adams, F.R.S.—Report on the Fossil Elephants of Malta.

W. Boyd Dawkins, M.A., F.R.S.—On the Physical Geography of the Mediterranean during the Pleistocene Age.

Charles Moore, F.G.S.—On the Presence of Naked Echinodermata (*Holothuria*) in Oolitic and Liassic Beds.

John Edward Lee, F.G.S.—Notice of Veins or Fissures in the Keuper filled Rhætic Bone-bed at Goldcliff in Monmouthshire.

Robert Sim, M.D.—On Certain Quartz Nodules occurring in the Crystalline Schists near Killin, Perthshire.

W. Molyneux, F.G.S.—On the Occurrence of Copper and Lead Ores in the Bunter Conglomerates of Cannock Chase.

T. Ogier Ward, M.D.—On the Formation and Stratification of Sedimentary Rocks.

T. Ogier Ward, M.D.—On Slickensides, or Rubbed, Polished, or Striated Rocks.

T. McK. Hughes—On the Announcement by Mr. J. W. Judd of Cretaceous Rocks in the Western Islands of Scotland.

Prof. Tennant—To Exhibit Specimens of Diamonds from the Cape of Good Hope.

E. R. Readwin—On the Arigna Coal and Iron District of the West of Ireland.

REPORTS AND PROCEEDINGS.

Geologists' Association. — July 5, 1872. — J. U. Ilott, Esq., in the Chair.—1. "*Corbicula fluminalis*, its Associates and Distribution," by Alfred Bell.

Having traced the distribution, both in place and time, of *Corbicula fluminalis*, the author pointed out its value in discriminating various geological horizons, especially in the valley of the Thames, and commented on the peculiar distribution of the different species of *Unio* associated with it, *Unio littoralis* only occurring in the gravels and brick-earth of Kent, at Crayford, and Erith, and *Unio tumidus* and *Unio pictorum* being equally confined to those of Essex and Middlesex, at Grays, Ilford, and Hackney Downs.

The difference in the size of the Corbicula from these localities was also noticed, and the inference suggested from these peculiarities was, that the Essex gravels and brick-earth were newer than those of Kent. All these were, however, anterior to those gravels in the Thames Valley which have yielded palæolithic flint implements, none of which have produced either the *Corbicula* or *Unio littoralis.* A cast of a flint flake found at Crayford by the Rev. Osmond Fisher below the Corbicula-beds was shown by the author, who did not concur in its being indicative of the presence of man at that early date, since, he considered, natural agencies were equally capable of producing such flakes.[1]

2. "On the Dip of the Chalk in Norfolk, and the Remains of Old Land-surfaces called the 'Stone-bed,'" by John Gunn, M.A., F.G.S.

Mr. Gunn showed that the dip of the Chalk from Hunstanton to Yarmouth averaged twenty-nine feet per mile. This he arrived at by computing the extent of the surface of the Chalk from Norwich to Yarmouth, where the Chalk was reached by the boring of an artesian well, and the extent of the base of the Chalk from Hunstanton to Norwich, where it was perforated by a similar boring. On this inclined plane of the Chalk, the strata were successively

[1] The flake in question is undoubtedly of human workmanship. See Geol. Mag. 1872, Vol. IX., p. 268.—Edit. Geol. Mag.

deposited : First, the Lower Tertiaries, then Antwerp beds, then the Forest-bed, then Freshwater, then Fluvio-marine beds (including the Norwich Crag), then, in increasingly deeper water, the Chillesford Sands and Clays (including the Aldeby or Taylor's Crag), then the Marine pebbly-beds, and then the Lower Boulder-clay.

This succession of strata is borne out by the Mammalian remains, which are found in the Stone-bed upon the surface of the Chalk, which consists of flints abraded from the Chalk. To such an extent has it been abraded by pluvial action and strong currents, that the Chalk at Hunstanton is reduced to nil; and there can be no doubt it was once deposited there, as in other parts of the county, from the immense masses of Chalk-with-flints which are bouldered in that district.

The Mammalian remains consist of the *Mastodon Arvernensis*, the *Elephas meridionalis*, and a great variety of deer and other animals! The *Mastodon* is found in the Stone-bed associated with the *Elephas meridionalis*, but is not found in the Forest-bed. The *Elephas meridionalis* abounds in the Forest-bed, but has not been discovered in the Fresh-water, or Fluvio-marine beds, including the Norwich Crag. The so-called "Mammaliferous Crag," when united with the Stone-bed, was said to yield the *Mastodon* and *Elephas meridionalis*, but is now proved to be almost non-mammaliferous. Mr. Gunn also pointed out that the Bone-bed in Suffolk, upon the surface of the London Clay, containing the debris of Miocene-beds, is formed under similar conditions to the Stone-bed in Norfolk, and that the changes of the fauna indicate the long periods of time occupied by these several and respective formations.

CORRESPONDENCE.

UNIO LIMOSUS, NILSSON, IN THE CRAG.

Sir,—It is so seldom that the opportunity offers of adding to the lists of fossils of the Post-glacial freshwater gravels, any species foreign to the present British fauna, that the discovery of a fine Unio may be regarded with some interest. The species referred to is the *Unio limosus* of Nilsson, Hist. Moll. Succ., p. 100, and is figured by Rossmasler, *Iconographie*, fig. 199. It lives in the rivers of Sweden, Denmark, and Northern Germany. My largest specimen measures $2\frac{5}{8}$in. lat. $1\frac{1}{8}$ long. Locality, Barnwell, near Cambridge. Mr. Jesson, I believe, was the discoverer of this interesting addition to our fossil fluviatile fauna.

Alfred Bell.

PURPURA LAPILLUS IN THE CORALLINE CRAG.

Sir,—With reference to the article in your last Number, on a fossil *Hydractinia* from the Coralline Crag, by Dr. Allman, enveloping two specimens of *Purpura lapillus*, I would remind your readers that this Mollusc is at present unknown from the Cor. Crag. Has Dr. Allman found it?

Searles V. Wood.

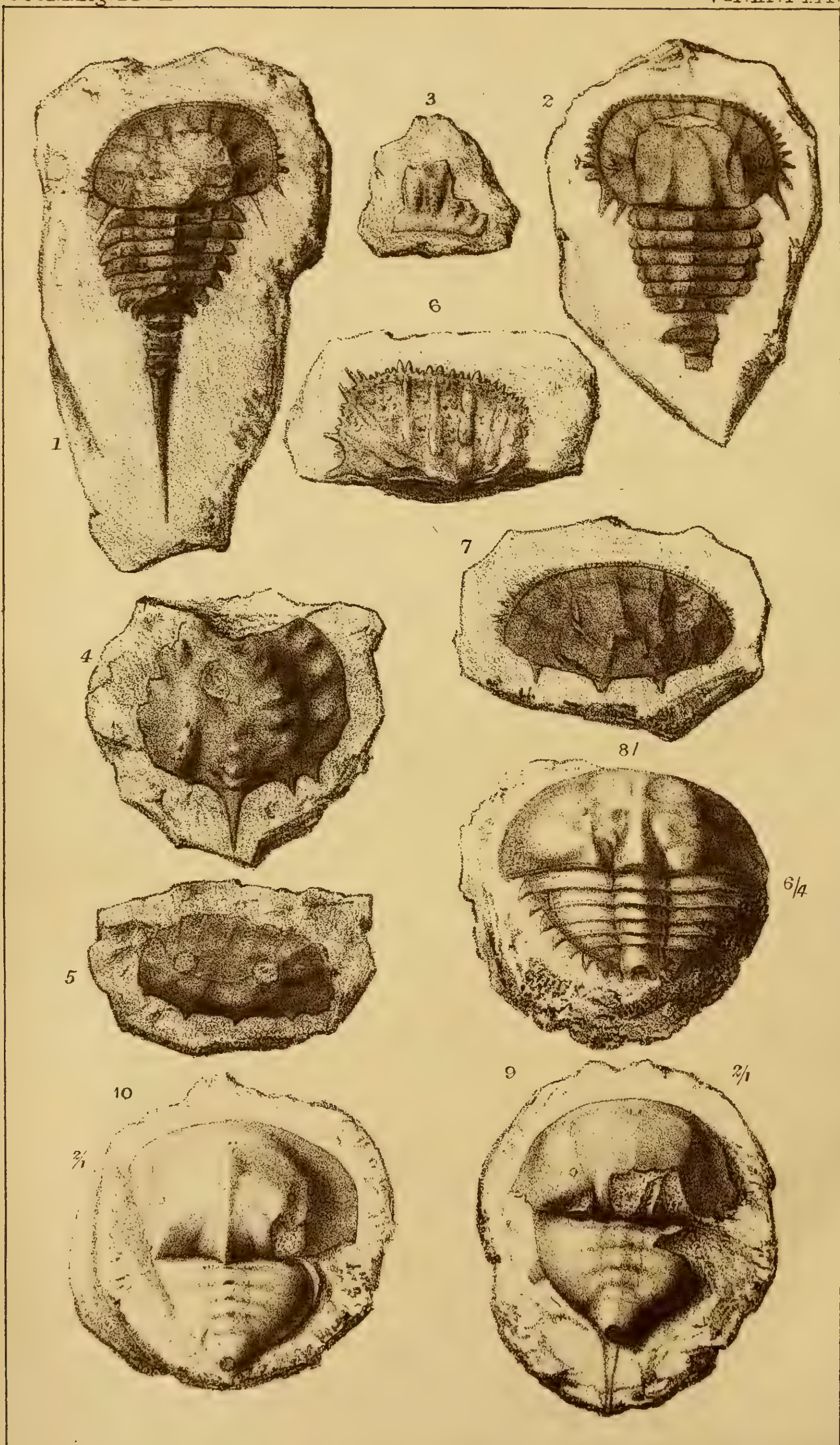
Brentwood, Essex.

MISCELLANEOUS.

Geology of the Straits of Dover.—The subject of a railway connexion between England and France has for some time past busied the minds of Engineers. Proposals have been made for a Bridge over the sea, a Tube on its bed, and a Tunnel beneath the bed of the sea. With the third scheme many geological considerations are of course involved, and we are glad to see that the subject has been ably discussed by Mr. W. Topley, F.G.S., in the Quarterly Journal of Science, for April. Plans for tunnels in two positions have been put forward, the one to be made wholly through the Chalk between Dover and Calais; the other through the Lower Greensand, and probably the Wealden and Upper Oolites, between Folkestone and Cape Gris-nez. Mr. Topley points out the geological structure of the English and French coasts in proximity to these proposed tunnels, and gives a little geological map of the land with the probable outcrops of the formations beneath the water; though on this point he acknowledges there is not sufficient evidence for much exactness. The tunnel from Folkestone would pass through a number of different beds, the changes in which it would be difficult to estimate, for the Lower Greensand and Wealden beds thin out in a very remarkable manner towards the Continent. Moreover, in these beds a good deal of trouble might be expected from water. Mr. Topley therefore points out that the other tunnel from Dover would be the least difficult undertaking. It could be taken for most, if not all the way, through the Lower Chalk, and he shows that very little trouble need be anticipated from water in penetrating this formation. And lastly he mentions that there is no reason to suppose that any great fault will be met with during the progress of the work.

Eurypterus (*Arthropleura*) *mammatus*, Salter. This species was figured and described by Mr. J. W. Salter in 1863. (See Quart. Journ. Geol. Soc. vol. xix. pp. 81-87.) It occurs associated with plant-remains in the "Ferny metal" bed, Pendleton Colliery, near Manchester. It is only known from a series of fragments.

A recent examination by Mr. W. Carruthers, F.R.S., has fully confirmed the opinion of Mr. Henry Woodward, that these specimens (with two exceptions) are not Crustacean, but Vegetable-remains referable to the *Ulodendron*. The two portions not belonging to *Ulodendron* are referred to Jordan's genus *Arthropleura*, which may be a Crustacean, but is more probably a gigantic Arachnide; it is certainly not a *Eurypterus*.



Mintern. Bros. imp.

Palæozoic Crustacea.

THE

GEOLOGICAL MAGAZINE.

No. C.—OCTOBER, 1872.

ORIGINAL ARTICLES.

I.—Notes on some British Palæozoic Crustacea belonging to the order Merostomata.

By Henry Woodward, F.G.S., F.Z.S.;
of the British Museum.

(PLATE X.)

On the Genus *Hemiaspis*, H. Woodw., 1865.[1]

Species 1.—*Hemisaspis limuloides*, H. Woodw., Pl. X., Figs. 1 and 2.

When I first drew attention to this genus at the Bath Meeting of the British Association in 1864, only one nearly perfect specimen was known. Mr. Salter was acquainted with this form, so long ago as 1857, and referred to it, among other new and undescribed Crustacea, in a paper "On some New Palæozoic Star-fishes" found at Leintwardine, Shropshire,[2] under the name of *Limuloides*. Portions of several others had also been met with, to which Mr. Salter attached MS. names in the Museum of Practical Geology, Jermyn-street, but they have not been heretofore described. The most perfect of these Limuloid forms was described by me in a paper read before the Geological Society in June, 1865.[3] (See Plate X. Fig. 1.)

Since that date other fragments have been found, and also another nearly perfect example (obtained by the late Mr. Henry Wyatt-Edgell) of the form named by me *Hemiaspis limuloides*, which, having the upper central portion of the carapace preserved, nearly completes our knowledge of this species. (See Pl. X. Fig. 2.) The great interest attaching to this form arises from the fact that it offers just the desiderated link by which to connect the Xiphosura with the Eurypterida. *Limuli*, apparently differing but little as regards their carapace from the recent species now found living on the coasts of China, Japan, and the north-east coast of North America, occur as early as the deposition of the Solenhofen Limestone of Bavaria; and in the Coal-measures of England and Ireland several species of *Bellinuri* and *Prestwichiæ* occur, in which behind the cephalic shield the body is composed of five more or less free thoracic segments, and the rudimentary abdomen, if not anchylosed in all, is so in most. (See Plate X. Figs. 8, 9, and 10.)

[1] Extracted from the Author's Memoir on the Merostomata, Part iv. p. 174. Pal. Soc. Mon., vol. for 1872.

[2] See Ann. and Mag. Nat. Hist., 2nd series, vol. xx., 1857, p. 321.

[3] See Quart. Journ. Geol. Soc., 1865, vol. xxi., p. 490, pl. xiv., fig. 7.

But in the specimen under consideration we have the cephalic, thoracic and abdominal divisions still remaining distinct, and apparently capable of separate flexure. This important character at once separates it from *Limulus, Bellinurus*, and *Prestwichia*. I have on this account[1] not used the MS. name of *Limuloides* as a generic appellation, but have proposed the name *Hemiaspis* (from ἥμιους, *half*, and ἀσπὶς, *a shield*), reserving the MS. name *Limuloides* for the specific title of the most perfect species of the genus. (See Plate X., Figs. 1, 2.)

But it will be observed that *Hemiaspis* is also, *in general appearance*, strongly severed from the other species of Eurypterida, as well as from the Xiphosura, in structure.

The three divisions into head, thorax, and abdomen are more strongly marked. The abdomen is reduced to very slender proportions, less than one-third the length of the animal (the entire specimen measuring 2½ inches in length by one inch in width).

The carapace in general outline resembles *Limulus*, but is more dilated laterally. There is a small stellate ornamentation in the centre of each cheek, having five to six rays, and measuring about a line in extent; but whether this represents the position of the eyes I am quite unable to say. It is unlike the eye of any other member of the group, which causes me to doubt its relation to that organ. It seems more probable that the eyes were placed along the lateral margin of the glabella, not upon the centre of the cheek.

There is a faint indication on one side of Fig. 1 and on Fig. 2 of a facial suture to the head-shield (as in the Trilobites), with a small aperture upon its border, which may possibly indicate the true position of the eye, but it is by no means clearly defined.

The surface of the glabella when perfect (as in Plate X. Fig. 2) appears to have been almost smooth,[2] save that it is traversed by two ridges which, commencing as raised tubercles on the posterior border of the head-shield, three lines apart, gradually converge and unite, so as to form an arch, the summit of which nearly touches the front border of the glabella.

Nine ray-like corrugations descend from the glabella towards the margin of the shield, and the whole surface of the carapace is very minutely granulated. The head-shield is armed, on each side, near the rounded posterior angles, with two principal spines directed backwards, whilst a fringe of lesser ones ornaments each lateral genal border.

The thorax is composed of six strongly trilobed plates, the epimera being equal in breadth to the central portion of each segment.

The first segment is the largest, being 1 line in depth and 7½ in breadth, including the epimera, which are pointed at their extremi-

[1] With the concurrence of Mr. Salter given at the time.

[2] In the original description of the glabella of *Hemiaspis limuloides* (see Quart. Journ. Geol Soc., 1865, vol. xxi. p. 490) I have described the glabella *from a detached portion*, "as ornamented with a semicircle of nine tubercles, and a tenth immediately within the circle upon the elevated front, and two small tubercles at the posterior margin." The acquisition of the second specimen (Plate X. Fig. 2) proves this fragment to belong to another species, not to *H. limuloides*, as formerly supposed.

ties, and slightly overlap the following segment. The four following segments have the borders of their epimeral pieces rounded, and gradually decrease in breadth downwards from 9 lines to 7, and increase in depth from ½ line to 1 line.

A section of one of the segments would present an outline like that of *Phacops* among the Trilobites, namely, a triple corrugation.

The 6th thoracic segment is more strongly arched than the preceding ones, and the lateral borders are divided into two rounded lobes on each side; breadth 5 lines, depth 1 line.

The abdomen consists of only three segments, each 2 lines in breadth, and 1½ line in depth. The first has no epimera, and appears to move freely at its articulation with the last thoracic segment. The second and third segments have small epimeral pieces, which are bilobed, with the posterior lobes more pointed. A line of small tubercles runs down the centre of these three joints, which are somewhat raised at their articular borders.

The telson is 12 lines in length and 1¼ line in breadth where it articulates with the abdomen; it tapers gradually to a fine point.

If we regard the first six body-rings from the head as thoracic, and the remaining three segments as abdominal, we must presume that each of these latter is a double segment, as compared with the segments of the *Eurypterida* proper.

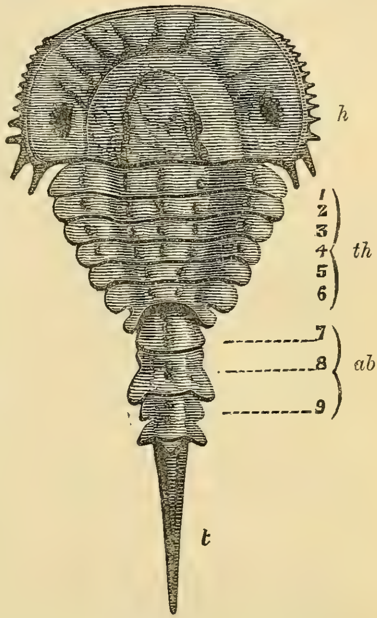


Fig. 1.—*Hemiaspis limuloides*, H. Woodward, L. Ludlow, Leintwardine.
h, the head; *th*, the six thoracic segments; *ab*, the three abdominal somites; *t*, the telson.

On the other hand, the presence of these three segments precludes our considering the head to be the cephalothorax and the succeeding segments the abdomen, a view controverted by me in my paper on the structure of the *Xiphosura*.[1]

The smallness of the abdomen, and its reduction from the assumed normal number of six to three segments, seems to indicate a form by which, with the help of others, we may bridge over the interval that has heretofore existed between these two groups, the *Eurypterida* and the *Xiphosura*.

Although *Hemiaspis* is the only genus met with in Britain having this remarkable form, we know of three Russian genera which present almost identical peculiarities of structure. Dr. J. Nieszkowski has described two forms from the Upper Silurian of the Island of

[1] See Quart. Journ. Geol. Soc., 1867, vol. xxiii. p. 28, plates i. and ii.

Oesel, namely, *Pseudoniscus aculeatus* (Woodcut, Fig. 2), and *Exapinurus Schrenkii* (Woodcut, Fig. 3); and Prof. Eichwald has described a third form under the name of *Bunodes lunula* (Woodcut, Fig. 4) from the same rich locality and formation.[1]

FIG. 2.

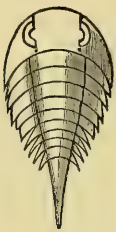


FIG. 3.

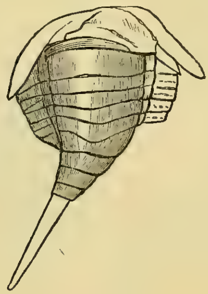


FIG. 4.

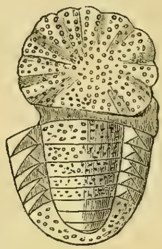


FIG. 2.—*Pseudoniscus aculeatus*, Nieszk.
FIG. 3.—*Exapinurus Schrenkii*, Nieszk.
FIG. 4.—*Bunodes lunula*,[2] Eichw.
All from the U. Silurian I. of Oesel, Baltic.

All these forms show three well-marked divisions to their bodies, namely, head, thorax, and abdomen, and all (save *Bunodes*) possessed a telson, or tail-spine, and free articulated thracic somites.

In addition to *Hemiaspis limuloides*, already described, there are certain other specimens in the Museum of Practical Geology, to which Mr. Salter has appended MS. names, namely—

Hemiaspis (*Limuloides*) *speratus*, Salter, MS.
,, ,, *optatus*, ,,
,, ,, *tuberculatus*, ,,

In Lowry's chart of the genera of Fossil Crustacea designed by Mr. J. W. Salter and myself, Mr. Salter has figured a head-shield of *Hemiaspis* under the name of *H. Salweyi*. There can be no doubt that this form is identical with *Limuloides tuberculatus* of Salter. I consider his *Limuloides speratus* and *L. optatus* to represent but one species, closely allied to *H. limuloides*. A portion of the head-shield of another form distinct from the foregoing, from the Wenlock shale, Dudley, completes the known species of *Hemiaspis*.

Species 2.—*Hemiaspis speratus*, Salter, MS. sp., Plate X. Figs. 5 and 7.

This species is represented by four head-shields only; the body-segments are not known. *Limuloides optatus*, Salter, MS., is not specifically distinct from *L. speratus* of Salter, and is consequently not retained.

It is no doubt closely related to *H. limuloides* already described, but the carapace is broader in proportion to its length, and the radiating lines or ridges which in that species take their rise around

[1] 'Archiv für die Naturk. Livonia, Esthonia, und Kurlands,' erste serie, zweiter bd., tab. ii. figs. 12, 13, and 15, pp. 378–382. (Dorpat, 1859.) 8vo.

[2] It is just possible that Bunodes may prove to be an Arachnid related to Scudder's *Architarbus rotundatus* from Illinois, U.S., and *A. subovalis*, H. Woodward (see GEOL. MAG., 1872, Vol. IX., September number, p. 385, Pl. IX. Figs. 1 and 2).

the margin of a well-defined central glabella, in *H. speratus* extend over the whole surface, save a small quadrate area at the centre of the posterior border. From this small area seven diverging costæ are given off: the three in front being nearly equidistant and straight, the two next, which rise from the outer angles of the central area, divide and form a **Y**-shaped ridge on each latero-anterior border; the two most posterior costæ curve upwards and outwards from the posterior border of the glabella to the lateral margins of the shield, and are marked midway by a minute lenticular space, which probably indicates the position of the eye (see Woodcut, Fig. 5, *e*).

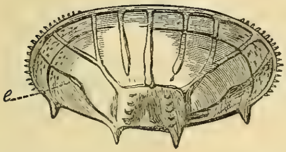


FIG. 5.—Head-shield of *Hemiaspis speratus*, Salter, MS. Nat. size. (Restored.) *e*, probable position of the eye.

The head-shield is broadly-arcuate in front, and the margin, especially on the cheeks, is fringed with a closely set row of minute spines; the lateral angles of the shield are truncated, not produced posteriorly; the hinder border of the head-shield is armed with four equidistant spines. The surface of the carapace, especially around the border, is covered with a very minute granular ornamentation. The following measurements show the relative size of the head-shields of *Hemiaspis speratus*:

Breadth.	Length.	
15 lines	7½ lines	(Plate X. Fig. 7), Mus. Brit.
10½ ,,	6 ,,	(,, Fig. 5) ,,
13 ,,	9 ,,	Mus. Pract. Geol.
12 ,,	9 ,,	,, ,,

This species is found in the Lower Ludlow Rock of Leintwardine, and is represented by specimens of the head only, preserved in the British Museum, and in the Museum of Practical Geology, Jermyn Street.

Species 3.—*Hemiaspis horridus*, H. Woodw., Plate X. Fig. 6.

This species, represented by a single example obtained by Charles Ketley, Esq., from the Tunnel shale, Dudley, and now preserved in the British Museum, is the oldest example in time of this curious genus.

When entire the carapace must have measured 1¼ inch in breadth by 8 lines in length; the edge is thickly set with prominent sharp-pointed spines ½ a line to a line in length, whilst two strong spines, 2 lines in length, project from each posterior angle of the carapace; the spines along the hinder border of the shield, if present in this species, are not preserved in this example. The median line of the carapace, which is slightly tumid, is marked by one rounded and prominent tubercle and two elongated confluent ones, whilst on either side of this median line three other divergent lines of

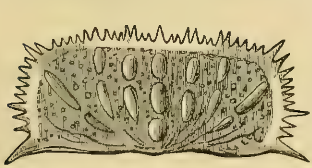


FIG. 6.—Head-shield of *Hemiaspis horridus*, H. Woodward. (Restored.) Wenlock shale Tunnel, Dudley.

elongated tubercles arise and radiate outwards to the border of the shield. The surface of the carapace between the tubercles is finely granulated, with here and there a slightly larger pimple upon its surface. Eyes not visible.

There are some other fragments which may indicate another species (see Plate X. Fig. 3), but they are too fragmentary for determination, and I therefore think it best merely to notice them in passing.

Formation.—Wenlock shale, Dudley. The specimen is preserved in the British Museum.

Species 4.—*Hemiaspis Salweyi*,[1] Salter, Plate X. Fig. 4.

This species is represented by two head-shields only; the body-segments, like those of the preceding species, are not preserved. The carapace, which is very tumid, is nearly circular in outline, and measures $1\frac{1}{2}$ inches in breadth and 1 inch in length. The posterior border of the glabella is armed with two large spines, 3 lines in length and 4 lines apart, whilst three smaller ones, also directed backwards, are arranged on either side of the genal border. The surface of the carapace is covered with a minute granular ornamentation; the raised central portion is flanked by a border of somewhat elongated tubercles; within the central area are three or four rounded tubercles arranged in two oblique rows about four lines apart, commencing on the posterior border of the head at the base of the two large spines; one central prominent tubercle and two lesser lateral ones on the front of the glabella, complete the ornamentation of the head-shield. The spot marked *e* on the subjoined Woodcut (Fig. 7), near the latero-anterior border of the raised glabella, probably indicates the position of the eye. There is a slight indication of costæ on the front border of the head.

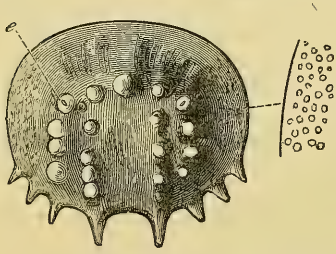


Fig. 7.—Head-shield of *Hemiaspis Salweyi*, Salter. (Restored.) U. Ludlow, near Ludlow.

Formation;—Upper Ludlow, near Ludlow (Mus. Pract. Geology, Jermyn St.); Lower Ludlow, Ledbury (British Museum).

Sub-order Xiphosura, Gronovan, 1764. Genus *Bellinurus*, König.

The name *Bellinurus*[2] was applied by Mr. Charles König, in 1820,[3] to a small form of *Limulus* from the Coal-measure Ironstone of Coalbrook Dale, Shropshire. The fossil was, however, unaccompanied by any description. Another specimen of the same

[1] *Hemiaspis Salweyi*, Salter, 1865. Lowry's Chart of Fossil Crustacea.

[2] From βέλος a dart, and οὐρὰ the tail.

[3] König, Icones Fossilium Sectiles, Centuria Secunda, pl. xviii., fig. 230. (London, 1820.)

species, also from this classical locality, is figured in Buckland's Bridgewater Treatise in 1836,[1] under the name of *Limulus trilobitoides.*

In a paper contributed to the "Annals and Magazine of Natural History" for February, 1863, vol. xi., p. 107, Mr. William Hellier Baily, F.G.S., gives an interesting account of the fossil Limuli, and defines König's genus *Bellinurus bellulus,* so that we may for the future adopt that name as the earliest.[2] Mr. Baily thus defines *Bellinurus bellulus,* König: "General form suborbicular. Head or cephalic shield semicircular, slightly arched; the central portion (or glabella) prominent and declining towards the circumference, surrounded with a flattened margin, and terminating at its posterior angles in long spines. Body[3] composed of five segments, which terminate in spines and diminish gradually towards the posterior extremity. Tail,[4] or caudal portion, small, with a few slight radiating divisions, to which is articulated an elongated spine (telson)."

Mr. Baily describes two new species of *Bellinurus* in his paper, namely:—

Bellinurus reginæ, Baily, Coal M., Bilboa Colliery, Queen's Co., Ireland.

Bellinurus arcuatus, Baily, Coal M. (loc. cit.)

In a communication made by me to the Geological Society in 1867, on the structure of the *Xiphosura,* already cited, I proposed to retain those forms of palæozoic *Limuli* with free and movable thoracic somites, and anchylosed abdominal ones, in the genus *Bellinurus,* and I referred those in which all the segments appeared to be anchylosed, namely (*Limulus*) *anthrax,* and (*L.*) *rotundata,* to the genus *Prestwichia.*

In all these species the body consists of a head-shield, five free, or anchylosed, thoracic segments, and three anchylosed abdominal ones. I have now to record two new forms of *Limuli* from the English Coal-measures.

1. *Bellinurus Königianus,* H. Woodward, sp. nov., Pl. X., Fig. 8. This new form was obtained from the Dudley Coal-field, and is quite distinct from the type-species *B. bellulus,* König.

The angles of the carapace are blunt, and not produced into long spines, and the five free thoracic somites terminate in obtuse serrations, not in recurved spines, as in *B. bellulus.* The thorax also is relatively broader in proportion to the head; the axis of the body is strongly arched and nearly straight, and does not diminish gradually towards the posterior extremity, as in the other species, although the pleuræ themselves contract to half their breadth from the first to the fifth segment. The raised circular border of the glabella is not so dis-

[1] Bridgewater Treatise on Geology an dMineralogy, vol. i., p. 396; vol. ii., p. 77, pl. 46″, fig. 3.

[2] Buckland's *Limulus trilobitoides* (1836), in consequence, becomes a synonym of König's *Bellinurus bellulus* (1820).

[3] Defined by the writer as the *Thoracic* series of segments.

[4] The rudimentary *Abdominal* segments coalesced. See memoir "On some points in the structure of the *Xiphosura,* having reference to their relationship with the *Eurypteridæ,*" by H. Woodward, Quart. Journ. Geol. Soc., 1867, vol. xxiii., p. 28, pl. i. and ii.

tinctly defined as in *B. bellulus,* but the central axis is more strongly marked. The eyes are not very well seen, but they occupy the same relative position on the margin of the raised glabella as in *B. bellulus.*

The abdominal division consists, as in the other species, of three coalesced segments, which are however only indicated by three marginal serrations.

The tail-spine (telson) is not preserved, but its articulation with the abdomen is strongly marked.

Greatest length of entire body, 9 lines.

Greatest breadth of head-shield, 1 inch.

Length of five free thoracic segments, 3 lines.

Breadth of first free thoracic segment, 10 lines.

Breadth of fifth free thoracic segment, 5 lines.

Breadth of central axis of body-segments, $2\frac{1}{2}$ lines.

I have named this species after Mr. Charles König, the original founder of the genus, and for many years the Keeper of the Geological and Mineralogical Collections in the British Museum. The original specimen is preserved in the British Museum, and was obtained by C. Ketley, Esq., from the Dudley Coalfield.

2. *Prestwichia Birtwelli,* H. Woodw., sp. nov., Pl. X., Figs. 9 and 10.

For a knowledge of this small but well-marked and very characteristic species of Coal *Limulus* I am indebted to Mr. Thomas Birtwell, of Gawthorpe Gardens, Padiham, Lancashire, who obtained it from the Coal-Measures at the Cornfield Pit on the south bank of the River Calder, near Padiham. It was from this pit that the new Arachnide (*Architarbus subovalis,* H. Woodw.) described in our last Number, p. 385, was obtained by Mr. Birtwell.

This new species (of which there are two examples, both figured in our Plate) exhibits the most complete anchylosis of its body-segments of any of the Coal *Limuli.* The entire body measures 8 lines in length, and 8 in greatest breadth; of this the head-shield measures 4 lines in length, and 8 in breadth; the anterior (thoracic) part of the post-cephalic shield is 6 lines broad, diminishing to 2 lines near the posterior (abdominal) part; length of the thoracico-abdominal somites 4 lines. The telson measured 4 lines in length. The head-shield is very tumid, the posterior genal angles are not produced; the glabella is divided down the centre by a slender ridge, its front border (as in most other species) forms two arches, between which and in the front of the head-shield, the larval eye-spots are seen; the small compound eyes are placed midway upon the lateral border of the glabella.

The divisions of the thoracico-abdominal segments are only faintly indicated along the central axis of the body; the margin does not show the usual serrations or spines, as in the other species; but the number of segments appears to have been the same. The coalesced abdominal segments were marked by a very prominent spine or tubercle, the top of which has however been broken off.

I have named this specimen *Prestwichia Birtwelli,* after its discoverer, Mr. Thomas Birtwell, in whose collection the specimens are preserved.

EXPLANATION OF PLATE X.

FIGS. 1 and 2. *Hemiaspis limuloides*, H. Woodw. Lower Ludlow, Leintwardine. Fig. 1 from the Museum of Practical Geology, Jermyn St.; Fig. 2 from the British Museum.
FIG. 3. Fragment of head-shield of *Hemiaspis*.
FIG. 4. *Hemiaspis Salweyi*, Salter. Lower Ludlow, Ledbury. Coll. Mus. Brit.
FIGS. 5 and 7. *H. speratus*, H. Woodw. Lower Ludlow, Leintwardine. Coll. Mus. Brit.
FIG. 6. *Hemiaspis horridus*, H. Woodw. Wenlock Shale, Dudley. Coll. Mus. Brit.
FIG. 8. *Bellinurus Königianus*, H. Woodw. Coal-Measures, Dudley Coal-field. Coll. Mus. Brit.
FIGS. 9 and 10. *Prestwichia Birtwelli*, H. Woodw. Coal-Measures, Cornfield Pit, near Padiham, Lancashire. Coll. Mr. Thomas Birtwell.

II.—ON THE CONTINUITY AND BREAKS BETWEEN THE VARIOUS DIVISIONS OF THE SILURIAN STRATA IN THE LAKE DISTRICT.

By W. TALBOT AVELINE, F.G.S.,
District Surveyor on the Geological Survey of England and Wales.

IN a former communication[1] I stated that the line of division between the Skiddaw Slates and the overlying Volcanic series (Green Slates and Porphyries), in the neighbourhood of Keswick, was a faulted one, and not an unconformity, as supposed by Mr. Dakyns.[2] I added that the evidence of an unconformity (if there was one), between these two series of beds, must be sought for elsewhere than in the district described by Mr. Dakyns. Since then I have examined many miles of boundary between these formations, and have as yet only seen one unfaulted junction, and this is near Bootle, in the Black Combe district, Cumberland; but this section at once sets at rest the question of unconformity or conformity. Not only do the Volcanic series lie at the same inclination with the Skiddaw Slates below them, but beds of the latter alternate with beds of the former, showing a perfect sequence and conformity. When the whole of the boundaries between the Skiddaw Slates and Volcanic series are traced, there may be found other spots also showing conformity and passage.

The most complete Break in the Lake District is that between the Volcanic series and the overlying Coniston Limestone; and here we have a considerable unconformity. For when the line of division, between these formations from the Granite at Shap to Black Combe is traced, it will be found that the Coniston Limestone series from lying on the highest known beds of the Volcanic series passes successively to lower and lower beds, till it finally rests on very low beds in the Black Combe district. So great is this unconformity that sometimes the beds of the Volcanic series strike at right angles to that of the beds of the Coniston Limestone.

In the Lake District the Coniston Limestone series of beds, which are equivalent to beds on the horizon of the Bala Limestone of North Wales, appear, on a cursory survey, to lie conformably beneath the overlying Upper Silurian rocks; but undoubtedly this is caused by the local accident of the Coniston Limestone series

[1] GEOL. MAG., Vol. VI., p. 382. [2] GEOL. MAG., Vol. VI., p. 56.

not being much disturbed before the deposition of the Upper Silurian, for there is not the slightest passage, either stratigraphically or palæontologically, from the Coniston Limestone series into the lower division of the Upper Silurian, which is the Stockdale Shales (including the Graptolitic Mud-stones), and these are equivalent to the Tarannon Shales or Pale Slates of North Wales. It is also seen, on a close survey, that the Stockdale Shales will occasionally partially overlap the Coniston Limestone series, and in one locality, I believe, completely; it will be also noticed that the strikes of the lower and higher series of beds do not always correspond.

III.—Remarks on the Genera *Trimerella*, *Dinobolus*, and *Monomerella*.

By Thomas Davidson, F.R.S., F.G.S., etc., and William King, Sc.D., and Professor of Mineralogy and Geology in Queen's College, Galway.

THE genera named in the title constitute in our opinion a new family belonging to the helictobrachial section of the class *Palliobranchiata* or *Brachiopoda.* We propose to designate it *Trimerellidæ,* after the type genus.

Although more or less treated of by other writers, we have been induced, especially by the desire of several intimate friends, who have kindly supplied us with the loan of some valuable series of specimens, and presented us with others, to undertake a further elucidation of a most difficult and enigmatical group of shells; and for this assistance our thanks are especially due to Lindström, Walmstedt, Billings, Hall, Whitfield, Meek, and others.

These "Remarks," it is necessary to state, are merely preliminary to a detailed memoir we have been preparing for some time past; and which we hope to have completed for the Geological Society in the early part of next session.

The Trimerellids differ much from all others of their class; though their proximate alliance to certain forms seems to admit of determination. We think there is little doubt of their being not only structurally related to the *Lingulidæ;*[1] but also genetically connected with this family. The first point is of considerable interest, inasmuch as the Lingulids are the *earliest* Palliobranchs that geologists are acquainted with, occurring in Cambrian rocks; while the Trimerellids do not seem to have been in existence prior to the next systemal group, all the forms belonging to the Lower and Upper Silurians. It would therefore appear that the Trimerellids, adopting the doctrine of genetheonomy (by which we mean evolution of species effected mainly through the operation of Divine laws, and not by purposeless or accidental modifications[2]), have been produced out of the Lingulids. Moreover, considering that the earliest Palliobranchs, taking them to be represented by the existing aniferous Lingulas, are of a simpler type than the non-aniferous Terebratulids

[1] For the present we place *Obolus* and other related genera in the *Lingulidæ.* This does not prevent our regarding *Obolus* as typifying another family; but the allocation now adopted simplifies these "Remarks."

[2] See Geologist, vol. v. p. 254.

and Rhynchonellids that succeeded them, the conclusion suggests itself that the latter and *simpler* groups are the degraded successors of a type that existed in the earliest known Life-period of our planet.

Another matter for consideration is the fact that the Cambrian Lingulids were furnished with a framework of a horny or slightly calcareous nature, as was generally the case with their contemporaneous Cœlenterates and Crustaceans, making it doubtful that ordinary marine calcium compounds were important solutions in the seas of their period; while the fact that the Trimerellids had essentially a calcareous framework, as was the case with a vast number of their coeval organisms, seems to show not only that such compounds had increased in the Silurian seas, but further to support the conclusion that the family we are engaged with is a post-genetheonomic branch of the Lingulids. With the physical changes indicated, the shells of the Palliobranchs under notice underwent important modifications compared with the group from which they presumedly originated.

The Trimerellids are strongly differentiated by the variety and form of their parts. The species, in general remarkably distinguished by their massive umbonal region, have, speaking subject to correction, the ventral or rostral valve characterized with twenty-four different parts, and their dorsal one with sixteen. Many of the parts are so unlike what are seen in other families as to defy all attempts to determine their use or function. One consideration that strikes us forcibly is that parts, as the teeth, and cardinal process,—essentials in other Palliobranchs,—are exceedingly mutable, not only in a genus, but in a species: besides, they are rarely well defined. The teeth may be large and crude in certain individuals, but rudimentary or obsolete in others of the same species. The cardinal process may be a thick projecting lamina, or rude in shape and massive, or absent altogether. The deltidium seems to be less liable to modification: situated on a well-developed area, it is bounded by two rather prominent ridges, one on each side, with their inner and projecting terminations serving as teeth; and having the usual areal border on the outside of each of the deltidial ridges. The deltidium itself is, in general, wide, and transversely marked with strong lamina-like lines of growth: it presents the appearance of being excavated out of the areal face (or underlying solid portion) of the beak, agreeing in this respect with what obtains in *Lingula*. In our forthcoming memoir it will be shown that another part, the deltidial slope, further testifies to the close affinity between the Trimerellids and the last-named genus. The hinge or cardinal plate, which requires more explanation than can be given on the present occasion, is so variable in one species (*Trimerella Lindströmi*) as to be with difficulty recognized in some individuals. The hinge-wall, as will shortly be seen, is equally subject to variation. The umbo or beak presents itself under different appearances; being in one genus obtusely rounded and in the others remarkably prominent. Somewhat constant in form, according to species, it may be subconical and massive, or compressed into a thin V-shaped plate; in the former condition it may be solid, or double-chambered. The chambers are separated by either a thick, or a thin partition; and they are shallow and wide-mouthed, or long and tubular. We are not acquainted with anything strictly resembling the partition in other Palliobranchs. In *Pentamerus*, it is true, the umbonal cavity is divided by a medio-longitudinal plate, giving rise to two lateral chambers: in this last genus, however, the dividing plate is double, causing it, when a specimen is suitably struck with the hammer, to split lengthwise into two halves; but no such division has occurred to us in any specimens of Trimerellids. The undivided condition of the partition seems to be explained on the view that this part is a modified form of the hinge-wall. Passing to the parts seen in the general or valvular cavity of the Trimerellids, the principal are the great muscular platforms, of which an example occurs in each valve. A similar homologous duplication characterizes other families—Pentamerids, Leptænids, etc.; but this part generally occurs under a widely different shape. In the typical genus of the present family the platforms are elevated and doubly-vaulted, the vaults being tubular and separated by a partition. The latter part is continued beyond or in advance of each platform, where it becomes the ordinary medio-longitudinal septum. A tendency to the double-vaulting may be observed in the great muscular supports of a few other Palliobranchs, particularly *Leptæna Dutertrii*, in which the ventral one curves over and rests upon the medio-longitudinal septum, forming thereby a doubly-vaulted arch. But the nearest approach to this peculiarity, as pointed out by Billings, is undoubtedly presented by the genus *Obolus*, in which certain muscular scars, usually excavated, have an overlapping posterior margin: in *Crania* something similar is seen. The platform, with its tubular vaults and biconvex surface, reminds one of a double-barrelled pistol. With a pair of platforms of this kind associated, as is often the case, with a couple of tubular umbonal chambers, the interior of a Trimerella presents a singular appearance. In *Monomerella* both platforms are solid and slightly raised; and consequently the absence of vaults gives the interior of this genus a totally different aspect: the umbonal cavity, however, consists of two large chambers. *Dinobolus* has neither a vaulted platform, nor a chambered umbo. Each of the three genera contains species in which the platform varies considerably, being reduced to so rudimentary a condition that it is difficult to allocate them generically. Hall has been induced to raise an aberrant species of the kind to the rank of a genus, *Rhynobolus;* but this step appears to us to be attended with considerable disadvantage, as it would necessitate instituting a genus for every aberrant form. The scars are numerous and exceedingly complicated by the modifications of the different parts, as just pointed out. After some consideration we have abandoned the attempt to homologize them, except in a few cases. We think the posterior crescent, with its loop and lanceolate scars, corresponds to the post-aponeural impressions in *Lingula* and *Discina*. We are unable to specify which scars have been produced by the valvular muscles, except some situated on the platforms; and in respect of the latter, our efforts to identify them with the valvulars of *Lingula* (the nearest living representative as we believe) have not, it is to be apprehended, been attended with much success. We have for the reasons stated refrained as far as possible from employing names for the different scars implying their uses; and have, instead, simply given them names denoting their relative position, distinguishing the group in the dorsal valve from that in the ventral one by letters of a different type. Certain scars, or other parts, apparently occupying a similar relative position in the two valves, and which appear to be analogous, bear the same letters, but in a different type.

The geographical distribution of the Trimerellids is a matter of some importance. Eminently a Silurian group, one might have expected that the well-explored region, which the labours of Murchison have made classical, would have yielded an abundance of examples; but, it is remarkable, only a few specimens of a single genus, *Dinobolus*, and apparently the last of their race, have been met with in the Wenlock limestones and shales near Dudley, and discovered for the first time in 1852. Identical deposits in Gothland contain the same species: but a greater variety of the family occurs rather abundantly in rocks of the "Aymestry" age of that remarkable locality. Canada and adjacent districts in the United States have yielded the greatest variety of species, all of which, with the exception of *Dinobolus Canadensis* and *D. magnifica*, being referable to the Upper Silurians. The two species last named occur in the Black river limestone, a rock which appears to be equivalent to the Upper Llandeilos, or to the base of the Caradocs of this country. A species of *Monomorella* has also been found in Livonia (Russia) in rocks corresponding in age with those in which the same species occurs in Gothland.

Our labours on the Trimerellids have enabled us to confirm, for the most part, the conclusions of previous writers as to the number of species, and to determine the existence of some others. The three genera are severally constituted in species as follows:—

Trimerella grandis, Billings.
" *acuminata*, Billings.
" *Lindströmi*, Dall.
" *Billingsii*, Dall.
" *Ohioensis*, Meek.
" *Dalli*, Dav. and King.
" *Wisbyensis*, Dav. and King.
Dinobolus Conradi, Hall.
" *Canadensis*, Billings.
Dinobolus Galtensis, Billings.
" *Davidsoni*, Salter.
" *transversus*, Salter.
" *Woodwardi*, Salter.
" *magnifica*, Billings.
Monomerella Walmstedti, Dav. & King.
" *prisca*, Billings.
" *orbicularis*, Billings.

With one or two exceptions, all the species will be fully illustrated in five lithographic plates in our forthcoming memoir: in addition to which there will be two wood-cut plates of diagram-figures, explaining the various parts briefly noticed on the present occasion, and another showing the relationship of *Lingula* to the family.

IV.—On *Ortonia*, a New Genus of Fossil Tubicolar Annelides, with Notes on the Genus *Tentaculites*.

By H. Alleyne Nicholson, M.D., D.Sc., M.A., F.R.S.E.,
Professor of Natural History and Botany in University College, Toronto.

HAVING recently had the opportunity of carefully investigating the genus *Tentaculites,* I was led to the conclusion that several fossils of diverse zoological affinities had been included under this head, and that the prevalent differences of opinion as to the systematic position of this genus might be thus readily explained (American Journ. of Science and Arts, vol. iii., no. 15, 1872). Originally founded by Schlotheim in 1820 (Petrefact. i., p. 377), *Tentaculites,* as its name implies, was believed to comprise fossils which were nothing more than the slender terminations of the jointed arms of Crinoids. Modern palæontologists have been divided in opinion as to whether *Tentaculites* was truly referable to the Tubicolar Annelides or the oceanic group of the *Pteropoda*—most recent authorities placing the genus in the latter class. In point of fact the difficulty has really arisen from the circumstance that two dissimilar sets of fossils have actually been included under *Tentaculites;* some of these being genuine *Pteropods,* whilst others are equally genuine Tubicolar Annelides. As all the *typical* species belong to the first group, it follows that the genus *Tentaculites* remains a Pteropodous one; whilst the Annelidan forms must be referred to new genera.

The restricted genus *Tentaculites,* then, may be defined as including small shells which have the form of *straight* conical tubes, tapering towards one extremity to a pointed closed apex, and expanding towards the other to a rounded aperture. The shell is *free,* and its walls are thin, and are surrounded by numerous thickened rings or annulations, sometimes with intermediate striæ, over the whole or part of the length of the tube.

The two points by which *Tentaculites* may be distinguished from all homomorphous forms are—firstly, that the shell is *straight,* or if bent, regularly bent or curved; and secondly, that the shell is *free.* It is quite clear that if, as there is every reason to believe, the genuine forms of *Tentaculites* are truly referable to the *Pteropoda,* every example must conform to these two characters. No member of the genus can possibly have been attached to any foreign body; and none can have been irregularly twisted or bent. The shell in all genera of Pteropods is free, and in all is either straight or is *regularly* curved.

On the other hand, whenever we meet with apparent examples of *Tentaculites* which are attached parasitically to shells or other foreign bodies, or which have the shell irregularly contorted, we may be quite sure that we cannot be dealing with any Pteropod. We are dealing now with Tubicolar Annelides, and it is a matter of astonishment how close a superficial resemblance is presented between some of these and specimens of *Tentaculites* proper.

In accordance with the principles here laid down, I have already proposed the genus *Conchicolites*, to include Tubicolar Annelides, the tubes of which are attached socially in clustered masses to dead shells. The tubes are composed of short imbricated rings, and are ranged side by side, being attached by their smaller ends only. The genus is, so far as known, confined to the Lower Silurian rocks; and broken fragments are almost, or quite, undistinguishable from *Tentaculites* (American Journ. Science and Arts, vol. iii., no. 15, 1872).

I have now to found another genus for the reception of an allied but very distinct Tubicolar Annelide, which has been previously referred with doubt to *Tentaculites*. This genus I propose to name *Ortonia*, after Mr. Edward Orton, of the Geological Survey of Ohio, who has kindly furnished me with specimens. Only a single species is known to me, from the Lower Silurian (Hudson River group) of South-Western Ohio, where it appears to be a common fossil. It has been doubtfully identified with Hall's *Tentaculites flexuosa* (Pal. New York, vol. i. p. 92); and if this determination could be relied upon, I would gladly retain the above specific name. Hall, however, describes his species as being furnished with distinct internal transerve septa; and this structure is certainly altogether wanting in our fossil. I shall, therefore, adopt for the present form the name of *Ortonia conica*, in allusion to the form of the investing tube.

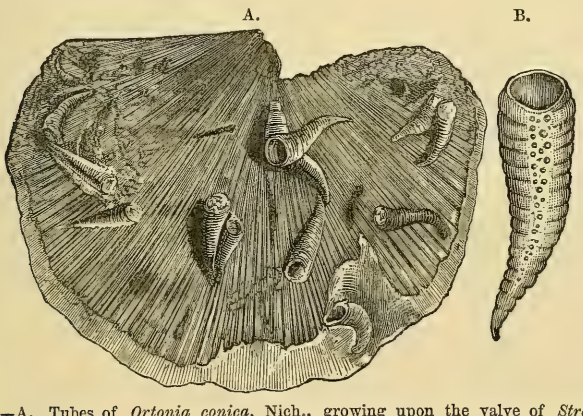


Fig. 1.—A. Tubes of *Ortonia conica*, Nich., growing upon the valve of *Strophomena alternata*. Nat. Size. B. A single tube of the same, enlarged.

The genus *Ortonia* comprises small conical calcareous tubes, which are found attached to the outer surfaces of the shells of Brachiopods or other Molluscs. Mr. Orton informs me that in one locality, at Cincinnati, the species confines its parasitism entirely to *Strophomena alternata;* but elsewhere it attaches itself to other shells as well. The tubes are attached along the whole of one side, full-grown specimens being from four to sixth-tenths of an inch in length. In shape, the tubes are markedly conical (Fig. 1B), their section being circular, or at times somewhat trigonal. Almost all the tubes, though in the main straight, are more or less curved and bent towards their smaller closed extremities. The widest extremity of the tube opens by a more or less nearly circular aperture; and the continuity of the tube, from its open to its closed extremity, is not interrupted by any internal septa. The surface-characters of the tubes are of a very remarkable character. Upon the surface, diametrically opposed to that along which the tube is attached to the shell, the tube is of a cellular character, exhibiting numerous rounded pits or *alveoli*, which strongly remind one of the peculiar cellular structure of the tube of *Cornulites*. This peculiar structure occupies a narrow belt running down the tube, along its dorsal or free surface; and from both sides of this belt there proceeds a series of strong annular ridges or rings which pass round the tube, to disappear on its fixed margin. These rings are not separated by secondary intermediate annulations; nor do they exhibit any longitudinal striation. Sections of the tubes, however, show that these rings are just as visible on the interior of of the tube as they are externally.

No reasonable doubt can be maintained as to the zoological position of *Ortonia*. It is unquestionable that we have to deal here with a true Tubicolar Annelide, nearly allied to the recent *Serpulæ*. *Ortonia* is still more nearly related to the extinct genus *Cornulites*, from which it differs in its much smaller size, and in being attached along the whole of one side, instead of by its smaller extremity only. It differs, also, in having the peculiar cellular structure of the tube confined to a definite portion of its surface, and in being altogether destitute of longitudinal striation. From *Conchicolites*, again, *Ortonia* is distinguished by the much more complete mode of its attachment, and by the fact that the tubes are never attached socially in clustered masses, growing side by side, as is the case in the former genus.

The following diagnosis gives the characters of the genus *Ortonia* and of the single known species:—Ortonia, Nich.—Animal solitary inhabiting a calcareous tube, which is attached along the whole of one side to some foreign body. Tube, slightly flexuous, conical, in section cylindrical, or somewhat flattened laterally, and sub-triangular. Walls of the tube thick, cellular along the surface opposite to the attached portion, markedly annulated along the sides.

Ortonia conica, Nich.—Tubes growing attached to the shell of some Mollusc; varying in length from $\frac{1}{4}$ to $\frac{1}{2}$ inch, with a diameter of about $\frac{1}{10}$ of an inch at the mouth. Lateral annulations of the tube varying in number from 30 to 35 in the space of an inch. Surface smooth and completely destitute, so far as observed, of longitudinal striæ.

The fossil from which the above description has been taken is an example of *Strophomena alternata*, to the dorsal valve of which are attached the remains of more than twenty individuals of *Ortonia conica*. In one case the tube of one crosses that of another individual; but it is quite clear that this is an accidental circumstance, so to speak, and that the tubes are truly solitary. The specimen is from the "Cincinnati group" of South-Western Ohio, a formation which belongs to the "Hudson River series," and which corresponds with the Caradoc or Bala division of the Lower Silurian.

In conclusion, I may add that Mr. Orton has submitted to me a beautiful specimen, apparently of the *Tentaculites tenuistriata* of Messrs. Meek and Worthen, also from the Cincinnati group of South-Western Ohio. If this specimen be rightly determined, I cannot avoid the conclusion that it is truly referable to the genus *Cornulites* of Schlotheim—differing from the familiar *Cornulites serpularius* in its small size, and in some other minor characters. This conclusion, however, does not admit of complete verification except by the discovery of specimens absolutely attached to some foreign body.

V.—Account of an Expedition to Greenland in the year 1870.

By Prof. A. E. Nordenskiöld,

Foreign Correspondent Geol. Soc. Lond., etc., etc., etc.

Part IV.

(*Continued from page* 427.)

SOMEWHAT further to the west of Karsok, and about 50 feet higher up, occurs another similar stratum, containing a mass of graphite, so soft that it may be cut with a knife. This spot was not, however, accurately examined. A similar stratum of graphite imbedded in sand and clay occurs also at a very great height above the sea at Niakornet, but time did not admit of our visiting that spot.

The graphite from Karsok is perfectly compact, without any signs of cleavage. On being heated, some pieces decrepitate violently and yield water. An analysis by Dr. Nordström gave:

	I.	II.	III.
Carbon	93·70	95·68	95·42
Hydrogen	0·69	0·22	0·27
Ash	4·92	3·60	3·60
	99·31	99·50	99·29

Part of the loss was probably oxygen. The ash contained per-oxide of iron, alumina, and 50 per cent. of silica; so that even these analyses indicate that this mineral is much nearer pure graphite, with which it fully agrees in appearance, than the coal that is usually found in these formations.

In the strata belonging to this division we found plant-remains at the following places:—

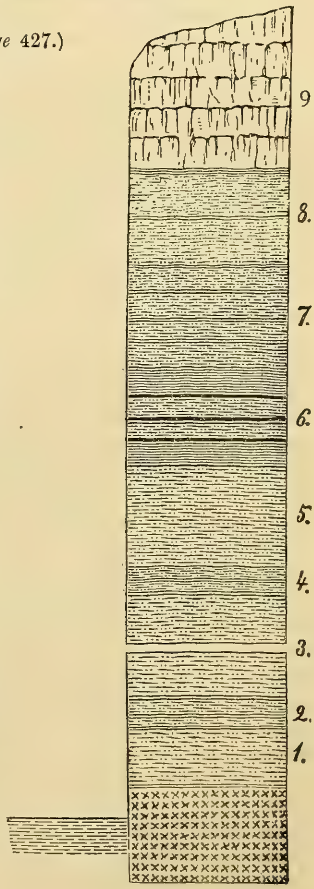


Fig. 9. Succession of strata at Ekkorfat.

1. *Ekkorfat.*—The strata here rest

upon a red gneiss, with a tendency to break off in scaly flakes, thus forming rounded hills on the shore. Nearest to the gneiss, at an inconsiderable distance from the strand, a little above the level of the water:

(1) (Lowest) Hard sandstone, unfossiliferous (60 feet).
(2) Carbonaceous slate, with sandstone and coal-bands, interstratified with thin layers of leaves of Coniferæ (30 feet).
(3) Hard red and white sandstone (300 feet).
(4) Red sandstone, with bands of slate and evident ripple marks (30 feet).
(5) Hard grey sandstone, almost like porphyry, inclosing round nodules of small stones and fragments of coal (100 feet).
(6) Alternating layers of sandstone and carbonaceous slate, with seams of coal, layers of harder slate, impressions of leaves, etc. (100 feet).
(7) Black slate and grey sandy slate with sandstone veins, no fossils (300 feet).
(8) Sandstone of uniform yellow colour, the upper part, for a depth of 200 feet, interstratified with grey slate, sandstone, and coal seams (300 feet).
(9) Basalt.

2. *Angiarsuit.*—Yellow sandstone, interstratified with grey slate, with seams of coal and impressions of plants; the same stratum as No. 8 (Fig. 9) at Ekkorfat. At Ekkorfat the strata, with the exception of occasional irregularities, dip towards S.W., so that nearer Karsok the yellow sandstone (8) reaches to the level of the sea. We thus had an opportunity of collecting fossils from this stratum, at a place called by the natives Angiarsuit, which, however, decidedly belong to the same formation as the fossils from the lower strata at Ekkorfat.

3. *Avkrusak.*—Fine impressions of plants are found here, near the shore, immediately under the sandstone, in horizontally-stratified slate.

4. *Karsok.*—The coast-land here, as has been mentioned above, is occupied by gneiss rocks, which, at a height of eight or nine hundred feet, are covered by a layer of slate containing fine impressions of ferns. The slate is, however, soon covered by gravel, so that the formation here is exposed only for a very limited distance close to the Karsok river.

5. *Pattorfik.*—For a distance of six English miles from Karsok the coast-land towards the fjord is occupied by gneiss; but on the other side of the river, at Pattorfik, first slate strata and then sandstone reappear close to the shore,—the first with particularly beautiful fossils, found principally in the beds nearest the gneiss. No extensive sections are however to be met with here, for the perpendicular exposed cliff, some yards above the surface of the sea, is covered with detritus of basalt, often hardened to a tuff-like mass, and inclosing the large subfossil shells mentioned above.

6. *Kome* or more properly Kook.—The former name, though grammatically wrong, ought however to be retained, as having been already introduced into science. The lowest portion of these strata forms on the shore an abruptly-terminated terrace of 80 to 150 feet high. Higher up the strata terminate in a gravel-covered slope,

scored by a number of deep ravines, which offer very clear sections of the various strata of the formation, for the most part nearly horizontal, or slightly dipping inwards towards Noursoak peninsula. The series is as follows (beginning at the top):—

On the brow of the hill................	*Basalt.*
About 1500 to 1200 feet above the level of the sea	*Thick banks of gravel*, concealing the strata below.
1200 to 1000 feet above sea-level	*Slate.*
	Sandstone.
1000 to 750 feet above sea-level	*Slate.*
	Sandstone.
	Slate, with seams of coal and a few plant-impressions.
	Sandstone.
750 feet above sea-level	*A thick stratum of coal.*
	Slate, with layers of sand.
	Sand.
	Slate.
	Sand.
	Sandstone, very loose.
150 feet above sea-level	*Carbonaceous slate, with bands of sand and coal.*
	A coal seam.
	Slate, with abundance of impressions of plants.
	Strata not exposed.
	Gneiss.

This section was taken in a ravine opening into the centre of Kome bay. The finest impressions of plants, however, occur in the neighbourhood of the house-sites, not far from the limit of the gneiss, which here forms a high mountain, immediately east of the river (Kook), which on that side seems to form the limit to the Lower Cretaceous beds of Greenland.

Thick as the Lower Cretaceous strata are, they are now visible only over a small area, as they only fill up the valleys between the gneiss hills by the coast. The strata at Kome are separated by gneiss hills from the strata at Pattorvik, and these again in the same manner from those of Karsok, Angiarsuit, Avkrusak, and Ekkorfat. The main mass of the formation, which evidently once extended over Omenak Fjord, is now washed away. Whether it extended inward into Noursoak peninsula under the basalt or not, it is impossible with certainty to say, as several of the deeper valleys are filled with ice. I however think this extremely probable, although the real Kome strata seem to be wanting at Atanekerdluk. They may possibly reappear between the last-mentioned place and the gneiss formation at Takkak. Calcareous strata are entirely absent in the Greenland Cretaceous, and it is useless to look for marine fossils there—everything shows that what we here have before us is a fresh-water deposit.

The fossils are most numerous and best preserved in the lowest strata, and consist principally of ferns and Coniferæ. Leaves of Coniferæ and other plant-remains are also met with, although rarely in the upper strata; but those found there, in consequence of their friability, can hardly be preserved. As regards these fossils, Prof. Oswald Heer has made the following communication:—

"All the places where these remains have been discovered (Kome, Avkrusak, Angiarsuit, Karsok, Ekkorfat, Pattorfik) have the same Flora, the character of which is marked by numerous ferns, among which the Gleicheniæ (*Gleichenia Rinkiana, Zippei, Gieseckiana*) play the chief part; by a remarkable Cycad (*Zamites arctica*), magnificent leaves of which are found, and by a large number of Conifers (*Pinus Crameri, Sequoia Reichenbachii, Widdringtonia gracilis*, etc.), and, in addition to this, by the almost total absence of Dicotyledons. The fine new discoveries tend to confirm the opinion I (Heer) have already expressed,[1] that this Flora belongs to the Lower Cretaceous, in all probability to the Urgonian strata. This is particularly shown by the beautiful Cycad, *Glossozamites Hoheneggeri*, discovered at Kome. The Greenland collections contain many specimens, which resemble the plants from Wernsdorff, which belong to the Urgonian, and have exactly the same character as those from Kome. Among the most remarkable new species from the Greenland Lower Cretaceous, a fine *Tæniopteris*, n. sp., an *Adiantum* (both from Avkrusak), and an elegant new *Sequoia* from Pattorfik, deserve special mention."

Fig. 10.

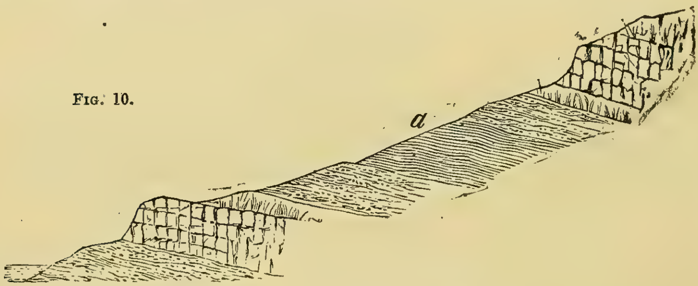


Fig. 10.—Series of strata below Atanekerdluk.

II.—*The Atane strata* (Upper Cretaceous, according to Heer).

These strata occur on the southern side of Noursoak peninsula, between Atanekerdluk and Atane, and probably also further on to the north on the eastern side of the Waigat. Some few, and not very clearly determinable, vegetable remains from Kome (750–1100 feet above the sea), and from the strata situated nearest the surface at Kudliset[2] (Ritenbenk coal-mine), probably belong to this formation, which contains more slate than either the subjacent Cretaceous strata or the superimposed Miocene beds, besides sand and loose sandstone, but no traces of limestone. The thickest Coal strata in Greenland—as well those at Atane (the richest I have seen in Greenland) as those near the surface of the water at Ipiit, and probably also those situated 750 feet above the sea at Kome—belong to this period. The same is probably the case with the strata inclosing retinite (not *amber*) at Hare Island. Small nodules of resin, however, occur in the Greenland Miocene.

[1] Heer's Flora Fossilis Arctica.

[2] The upper strata in the neighbourhood of Kudliset are Miocene.

The above profile shows the stratification at (Lower) Atanekerdluk. The mass of the formation consists of very fine black argillaceous slate (*a*), resembling the slate from Cape Starastschin, in Spitzbergen, containing a quantity of plant-remains, which, however, it is very difficult to preserve, in consequence of the brittleness of the slate. There are no marine fossils whatever here, so that it is evidently a fresh-water formation.

At Atane the adjoining cliffs nearest to the water's edge are concealed by stone and gravel, consisting partly of sandstone and partly of basalt and basalt breccia containing zeolite. Over these we have:

At 450 feet, horizontal strata of hard sandstone.

At 600 feet, argillaceous slate which soon alternates with sandstone.

At 650 feet, a thick coal-bed resting upon fine slate, with impressions of plants (Upper Cretaceous) and particles of resin. Then again slate, often interstratified with coal-beds of considerable thickness.

At 900 feet, a coal-bed two feet thick, from which on the side left bare by the ravine a white salt has fretted out (sulphate of alumina). On this is a stratum of sandstone 50 feet thick, then argillaceous slate, and over that sandstone again, and lastly basalt.

On the fossils from these places Professor Heer remarks: "The fossils from the lower strata at Atanekerdluk belong probably to the Upper Cretaceous. This appears from:—

"1. The presence of a remarkable Cycad (*Cycadites Dicksoni*). It is true that this is not altogether consistent with the supposition, that these impressions belong to the Eocene formation; but at any rate no Cycad, and especially no *Cycadites*, has hitherto been found in strata belonging to the Eocene epoch.

"2. The frequent occurrence of ferns.

"3. The occurrence of a *Sequoia*, which can scarcely be distinguished from *Sequoia Reichenbachii*.

"4. And of a *Credneria*, of which, however, only fragments are before us.

"On the other hand, this Flora differs entirely from that at Kome, especially by the presence of pretty numerous dicotyledonous leaves, which are, moreover, quite unlike the Greenland Miocene plants. The investigation of these fossils presents serious difficulties, as the greater part of them are those of full-bordered leaves with a complicated nervation offering but few fixed points of discrimination. One leaf seems to agree with *Magnolia alternans*, Heer, from the Upper Cretaceous of Nebraska.

"These dicotyledonous leaves indicate the Upper Cretaceous formation, but to which of its subdivisions the lower strata at Atanekerdluk are to be assigned can only be determined by a closer investigation. This new flora is, at any rate, one of the greatest discoveries of the Expedition of 1870, opening, as it does, for North Greenland an entirely new geological horizon, which shows that in the Arctic regions, as in Europe, *Dicotyledonous plants* do not occur in the Cretaceous beneath the Gault, whereas immediately above it they appear in a great variety of forms. In North Greenland then, as well as in Europe and America, the vegetable world has undergone great changes during the course of the Cretaceous age."

III.—*The Miocene formation.*

During the Miocene period masses of basalt, sand, and clay, to a depth of many thousand feet, have been piled together in the district of Greenland we are now considering, and by far the greater part of the rocks on Disko Island and Noursoak peninsula belong therefore to that epoch. The Greenland Miocene strata (of sedimentary and eruptive origin) may be arranged under three divisions, namely :

(*a*) *Lowest.* Sand or loose sandstone, with slate, coal-bands of slight thickness, and ferruginous clay-beds, very rich in impressions of plants.

(*b*) Basalt, Tuff, and Lava beds of several thousand feet in thickness, usually as regularly stratified as sand-beds, often alternating with basalt beds. In about the middle of this basalt formation layers of fossiliferous clay, sand, and ferruginous clay, of limited thickness, are met with.

(*c*) Loose layers of sand, and one or two bands of clay, deposited on the southern strand of the Isle of Disko, *between* the basalt rocks, and therefore more recent than them.

From all these localities, separated from each other by basalt strata of 2000 feet thick, numerous fossils have been collected, indicating according to Heer the Miocene period. As the strata are nevertheless in geological respects widely different from each other, I give an account of each separately.

III. *a.*—*Upper Atanekerdluk strata.*—At Atanekerdluk we meet with fossils from two different periods, namely : (1) 300—400 feet above the sea slate-beds with thin sand-layers and coal-seams (*e*),[1] containing fossils imbedded in black slate and belonging to the Upper Cretaceous (the Atane strata described in II.) ; and (2) thick sand-beds, with occasional bands of slate (*c*, *d*), containing but few fossils. At a height of 1000—1200 feet above the sea these layers of sand begin to be interstratified with a ferruginous clay, which, as well as the sandstone that occurs in its immediate vicinity, is remarkably rich in impressions of plants. The greatest part of the fossils that have been brought home from Greenland belong to this locality, of the discovery and scientific examination of which I have already given a succinct account. Here I will only add a few words on the hitherto imperfectly, and in part, inaccurately, described geognostic relations of the place.

By the name "Atanekerdluk," the Greenlanders properly designate a little peninsula, four hundred feet high, and connected with the main land only by a small isthmus, which in the southern part of the Waigat forms a projection from the cliffs of the land of Noursoak, which are bold everywhere else, and whose brow is elevated even close to the coast 3000 feet. The place was formerly the seat of a Greenland colony assembled round a Danish "outpost" (Utliggare), but is now deserted and uninhabited. Deserted house-sites and paths, which in Greenland remain unobliterated for a great length of

[1] See further on, Figs. 12 and 13.

time,[1] and a number of graves, still serve to remind us of the now dead or scattered little colony. The peninsula itself is formed of a rusty brown, rather coarse-grained dolerite, composed of two species of felspar (labradorite and sanidin?), titanic iron, crystallized in thin hexagonal laminæ and augite. In this it differs from the genuine Greenland basalt and basalt-tuff, although it evidently only forms the oldest link of the vast volcanic and plutonic chain of rocks of North-west Greenland. At the steep cliffs on the western side of the peninsula one can see even that dolerite is lying on sandstone of the same loose character as the superjacent sand and sandstone beds.

Immediately on the other side of the low isthmus, that rises only a few feet above the water, and unites this peninsula with the main land, we first meet with the above-described Atane strata (*e*), then follows sand, after which a basalt bed again, covered by layers of sand alternating with slate, and crossed by vast plutonic veins (a, a', a'', a'''), which seem not to have had the smallest influence on the sand through which they have broken. Only here and there a grain of sand is found melted or rather rusted into the surface of the dyke, the upper part of which now generally forms a ridge[2] standing up from the surrounding loose layers of earth. Between the layers of slate we find one or two small seams of coal, and in the sand here and there a carbonized stem of a tree, but no real impressions of leaves, till we come to a height of 1200 feet above the sea.[3] Here commences sand or sandstone mixed with clay, covered by a tolerably firm slate, and interstratified with thin beds of ferruginous claystone (*b*), often broken up into larger or smaller lenticular masses, and extremely rich in Miocene fossils. These occur not only in the ferruginous clay, but also in the surrounding somewhat hardened sandstone, and may perhaps be obtained from this sandstone in greater perfection than from extremely hard and unmanageable ferruginous clay. We often find in sandstone nodules and flat ellipsoids of ferruginous clay so full of remains of plants, especially on the surface, that it looks as if these nodules, before they had hardened and been imbedded in the sand, had been rolled in a heap of leaves. The ferruginous clay has, when newly broken, a dark grey fracture, which, by exposure to the air and the polishing effect of the sand, acquires as it were a polish and a brick-brown colour. Pieces of it are plentifully scattered about in the confined locality where these vegetable-remains occur. In the same sandstone, a little south of the spot where the impressions of leaves are met with, may be found at the edge of the glen, very deep at this spot, trunks of trees, the tops of which rise above the sand, or form black spots in the white sand. An excavation was made in our presence, and we

[1] Rink mentions paths still remaining in districts uninhabited since the time of the old Northmen colonists, and we ourselves could clearly distinguish at Kaja the paths round the long deserted house-sites there.

[2] The remarkably slight effect which the eruptive rock has produced on the surrounding layers of sand astonished Mr. Brown.

[3] 1084 Inglefield; 1175 mean of six measurements with the aneroid by Whymper; 1203 by the aneroid used by the Expedition of 1870.

saw, as the annexed woodcut indicates, the roots branch out in an underlying clay-bed. There can, therefore, be no doubt that these trunks once grew in the place where they are now found. Above these strata is sand, then a thick stratum of basalt, over which sand again, and lastly a basalt bed of perhaps 2000 feet thick, and, as far as one can judge from a distance, not interstratified with layers of sand or slate.

Fig. 11.

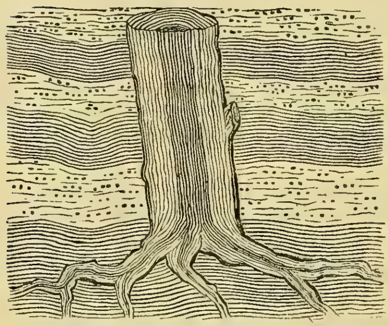


Fig. 11.—Bituminized tree stem from Atanekerdluk.

At Atanekerdluk itself the strata follow the direction of the strait (or, more correctly speaking, run true NNW. SSE.[1]), and the slope, as indicated in the following sections, taken from a ravine the direction of which was at right angles to the shore, is 8°–32° ENE. Further up in the strait the strata gradually sink, so that the capping of basalt, a little north of Atane, reaches down to the surface of the sea. The perturbations at Atanekerdluk, therefore, seem to have been only local, and on the whole the strata would seem to lie pretty nearly horizontal, with a slight dip to NW.

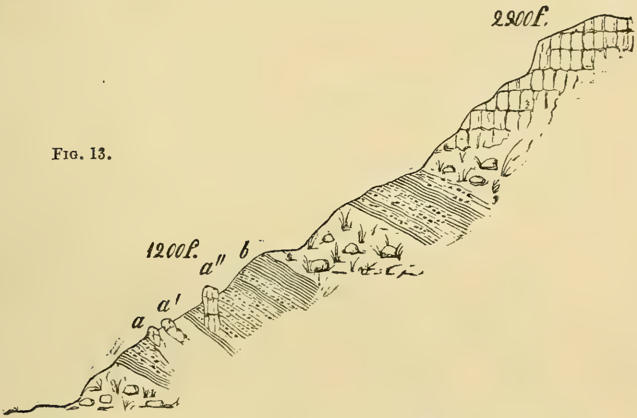
This Miocene formation has evidently in former times extended completely over the Waigat to Disko Isle, at the south-east angle of which it attains its greatest thickness. One may here see from the sea sandhills of 2000 or 3000 feet high, often, but not always, containing basalt-beds. The chief substance of the mountains consists of vast horizontal sand-beds, interstratified with thinnish beds of clay, and occasional horizontal coal-bands, and carbonized stems of trees, sometimes in their original position and of considerable size. A stem of this kind, two feet in diameter, was, for example, seen in a rock in the district about Mudderbugten. The quantity of carbonized stems of trees is often so great that it is worth the while of the Greenlanders to collect and use them as fuel. Silicified stems of trees are also met with, though more rarely. The greatest number of impressions of leaves occur on the western shore of the Waigat, as also at Atanekerdluk, almost invariably imbedded in hard, grey ferruginous claystone, that turns red by exposure to the corroding effect of the atmosphere ("Atanekerdlukstone"), which forms either peculiar beds of one or two inches thick and a few fathoms in extent, or lenticular masses imbedded in sand or clay, or small balls inserted in huge, almost spherical sandstone nodules, detached from the sand by the infiltration of some conglomerating medium, often of remark-

[1] Mean of several observations made in the ravine along the side of which I ascended this slope. Brown gives E. and W. as the direction. The difference probably arises from the circumstance that the magnetic perturbations at Atanekerdluk are of a local nature, and thus different in different ravines.

ably regular form and some yards in section. Atanekerdlukstone, like the nearest neighbouring sand and clay beds, always contains remains of leaves, which may then either form small separate layers

FIG. 12.

FIG. 13.



FIGS. 12 and 13.—Series of Strata at Atanekerdluk: the scale of the second section being about half that of the first.

or an isolated nodule in the sand of some few inches diameter; whereas it would be vain to look for impressions of leaves in the more distant sand-beds. Coal strata worth working probably do not occur in this horizon of the Miocene; at least the layers at Atane, the largest coal-beds at Kome, and at Ipiit near Kudliset, seem to *belong to the Upper Cretaceous*, while the strata at Netluarsak, Isorisok, the coal in the high fells at Skandsen and Assakak, belong *to the middle, not the lower horizon, of the Miocene of Greenland.* Probably also the coal-beds at Hare Island do not belong to this formation, as I have already observed.[1]

From the Lower Miocene strata at Disko Isle we collected fossils

[1] Dr. Nauckhoff's and Dr. Pfaff's discovery of Sigillaria makes it possible that the Coal strata of the Coal formation occur at Ujarasusuk.

at Flakkerkuk, the rocks adjoining Mudderbugten, Isungoak, Ujarasusuk, Iglosungoak. None of these localities is in richness to be compared with Atanekerdluk.

III. *b.*—*Ipsorisok strata.*—By this name I designate the thinnish layers containing fossils that occur imbedded in the basalt of the high hills. Such strata have been met with at—

Netluarsuk, between Noursoak and Noursak. A little north of Atane the basalt strata sinks down to the surface of the sea, and from a distance it is impossible to discover in the very regularly stratified basalt-beds, ending at the shore with a vertical section of several thousand feet, any sand or argillaceous slate-beds. Neither do the Greenlanders know of any other coal-beds in that neighbourhood than one which is met with at Netluarsuk, at an elevation of about 1000 feet. The strata are here for a distance of a few dozen feet exposed at a steep gorge between the basalt hills. They seem to be of trifling thickness, and consist of alternating beds of from 0·2 to 2 inches thick of sand, coal, slate, and a ferruginous clay, different in appearance from the ferruginous clay at Atanekerdluk, though, like it, full of fossils, chiefly of fir leaves and twigs, mixed with clay or coal. Among these fossils occur not only leaves and cones, but also seeds. The coal consists almost exclusively of flattened and carbonized stems.

Ifsorisok, a place situated about 12 miles from the coast, and 2250 feet above the sea. We visited the spot from Holländarbugten or Itiblit, situated a little to the north of Niakornet. Some distance from the coast we first find thick layers of a rock, which appears to be a much changed siliceous slate. Afterwards the path proceeds up steep slopes of basalt detritus and basalt rocks, or (at 2300 feet) extensive plains, covered with the same material, and, at the period of our visit, free from snow, though hardly clothed with any vegetation. Here one has to pass long distances over weathered and crumbling slabs of basalt, which show that the underlying rocks are everywhere composed of eruptive masses. From these plains considerable basalt hills rise further inward, among which Kinnitok—a lofty mountain ridge between Niakornet and Ekkorfat—is the largest. This mountain is probably 5000 or 6000 feet high, and, seen from a distance, appears also to be composed entirely of the eruptive rock common in these parts.

Somewhat beyond the spot where one passes the highest point of the plains are some shallow valleys. In the slope of one of them is the spot which formed the object of our visit. The place betrays itself by larger or smaller pieces of coal lying mixed with the basalt detritus, and, on digging here, sedimentary strata, consisting of caol-seams some inches thick, sandy clay, and fine, grey, hardened clay are discovered. The clay contains impressions of plants, and among the coal flattened and imperfectly carbonized tree-stems are met with. Silicified wood is also found in the gravel. The schists are evidently of no great thickness, but regularly stratified with a dip of about 10° towards the north.

Assakak.—Immediately south of Kome river, Noursoakland, nearest the shore is occupied by lofty gneiss rocks, between which a number of glaciers project. One of these, Assakak glacier, has long been celebrated for the charred tree-stems lying scattered on the surface of the ice. The glacier itself does not reach down to the sea, but is separated from the strand by a low foreland, covered with boulders of gneiss, and passing without any discoverable line of demarcation into the glacier, which is there also itself covered with gravel. The gravel, however, here principally consists of angular fragments of basalt, among which pieces of charred wood may be here and there remarked. Higher up the mass of charred or silicified wood increased considerably, and was often piled together as if by human hand. It was, however, easy to satisfy oneself that this was not the case, but that the coal came from some stratum in the neighbourhood of the glacier, on the surface of which it now lay scattered, chiefly at a height *estimated* by me at about 300 feet. The nearest high mountains surrounding the glacier seemed to consist of gneiss, hornblende slate, etc. A thick fog prevented us from seeing far inward, and induced us to defer an excursion we had intended in that direction, which probably, as far as the object of finding the stratum from which the pieces of wood had come is concerned, would not have been crowned with success. In fact, it is probable that the fragments of wood belong to a Tertiary stratum *beneath* the glacier. After a careful search, pieces of clay and sandstone were found, containing remnants of plants exactly similar to the fossils at Ifsorisok, whence I draw the conclusion, that the strata, where the coal has originated, were about contemporaneous with those of Ifsorisok and Netluarsuk.

The strata of this horizon are separated from the Lower Miocene strata at Atanekerdluk by basalt-beds several thousand feet thick, for the stratification of which an immense space of time must have been required, and one would accordingly expect to find here remains of a vegetation very different from the Miocene vegetation of Atanekerdluk. But this is not the case. According to Professor Heer, the fossils in both these places have a purely Miocene stamp. As evidence of this Professor Heer adduces the presence of *Sequoia Langsdorfii*, at Ifsorisok, and that of *Taxodium distichum*, *Glyptostrobus Europæus* and *Chamæcyparis massiliensis*, at Netluarsak.

IV.—*The Sinnifik strata.*

At Godhavn the basalt rests immediately upon gneiss, but only a little way to the east the eruptive rock reaches the sea-level, and in rowing here along the southern shore of Disko, one passes by cliffs of basalt-tuff and basalt, often (as, for example, at the Brännvinshamnen) broken up in the most splendid manner into hexagonal basalt columns, basalt grottoes, and basalt arches. On the other side of Brededalen the basalt first begins to be interstratified with sand and slate beds, which probably are the beginnings of those vast sand strata that meet us on both sides of the entrance to the Waigat.

Further on, at Puilasok and Sinnifik, the shore itself consists of sand strata, with very thin slate seams, here and there interrupted by basaltic cliffs, with a worn and smooth surface. The sand strata around the cliffs were not in appearance distinguishable from the sand still heaped by the action of wind and wave around the basalt rocks on the shore. Everything seems to show, that in many places hereabouts,[1] we have before us sand strata deposited between basalt rocks. In this case these layers are more recent than the whole basalt formation, and the fossils they contain, imbedded partly in an extremely brittle argillaceous slate, partly (at Sinnifik) in hard marl nodules resembling those at Atanekerdluk, but not containing very much iron, are of interest as indicating the limit of the period, during which this tract was the scene of the vast volcanic eruptions, which have given rise to the basalt masses of North-west Greenland. These fossils consist, at Puilasok, only of fragments of leaves of trees (*Salix, Myrica, Platanus aceroides, Cratægus antiqua,* etc.); at Sinnifik, both leaves of trees and Coniferæ (*Sequoia Langsdorfii, Taxites Olrikii, Populus arctica*), and, according to Heer, bear constant witness to a Miocene, perhaps an Upper Miocene epoch. If this be so, the volcanic agency in these parts commenced during the Cretaceous and terminated previously to the close of the Miocene period. The basalt-beds in the Cretaceous and Lower (Greenland) Miocene are, however, quite trifling in comparison with those which cover the Miocene deposits at Atanekerdluk, Ujarasusuk, Isungoak, etc. Accordingly in these (Greenland) districts the volcanic action has attained its greatest intensity in the Middle Miocene.

During our involuntary stay at Godhavn, I made an excursion, in company with some comrades, in a boat manned by Greenlanders, to the spot whence the Rudolph meteoric iron was supposed to have been taken, namely, the old whaling-station of Fortune Bay, situated in the neighbourhood of Godhavn. On arriving there, I ordered the Greenlanders to look after *heavy, round, rusty-brown stones, which I knew would certainly be found somewhere thereabout.* It was in vain. No meteoric stones, or rather pieces of meteoric iron, were on this occasion to be found; but before leaving the spot I again repeated to the Greenlanders, that pieces of iron of the nature described *were most unquestionably to be met with somewhere in that neighbourhood,* and I promised them a reward, if they could, against my return in the autumn, discover them.

When, at the end of August, we returned from Omenak to Godhavn, one of the Greenlanders communicated to me, with many lively gestures to express their size, shape, etc., that they had decidedly hit upon the stones I had described. A small specimen was shown, which really confirmed the statement.

The place where the iron masses were found was not, however, at Fortune Bay, but one of the shores most difficult of access in the whole coast of Danish Greenland, namely Ovifak, or the Blue Hill, which lies quite open to the south wind, and is inaccessible, even in a very moderate sea, between Laxe-bugt and Disko-fjord. I

[1] In this neighbourhood we even meet with sand layers lying beneath the basalt.

scarcely need mention that this discovery completely altered the plan for our further excursions. Our intention had been to employ the rest of our sojourn in Greenland in an examination of the basalt formations between Skandsen and Godhavn, and we had therefore, immediately on our arrival at Godhavn, hired two whale-boats manned with Greenlanders, with a view to rowing in short day-journeys with them along the coast of Disko to the eastward of Godhaven. These boats, on the morning when the discovery of the meteorites was made, lay ready and provisioned on the strand. We immediately set sail, and sailed favoured by a tolerably good wind, not eastward, but westward to Ovifak, where we arrived the same evening before sunset. The sea was calm, so that it was possible to land, and the very stone at which we lay to was itself a piece of meteoric iron, probably the largest piece as yet known. On searching more carefully we further discovered two large and a great number of smaller pieces of meteoric iron scattered over an area of a few square fathoms in the vicinity of the large stone.

The meteorites lay as on the accompanying map (Pl. VIII., Figs. 1 and 2)[1] and ideal section, between high and low water, among rounded gneiss and granite blocks, at the foot of a vast basalt slip, from which, higher up the perpendicular, horizontally stratified basalt-beds of Mount Ovifak projected. Sixteen metres from the largest iron block a basalt ridge of a foot high rose from the detritus on the strand, and could be followed for a distance of four metres, and was probably part of the rock. Parallel with this and nearer to the strand ran another similar ridge, also about four metres long. *The former contained lenticular and disk-shaped blocks* of nickel iron, in external appearance, chemical nature, and relation to the atmosphere (weathering), like meteoric iron. On being polished and etched this iron exhibited fine Widmanstädt's figures. The native iron lay imbedded immediately in the basalt, separated from it at the most by a thin coating of rust. Moreover, in that basalt, in the neighbourhood of the blocks of native iron, nodules were found of Hisingerite, evidently formed by the oxidation of the iron, as also small imbedded particles of nickel iron.

The meteorites themselves were of various colours, from that of tombac to rusty brown, and at least in some places had a metallic lustre on the surface. Here and there one could discover upon their surface and in the iron nearest the surface pieces of basalt or fragments of a crust of basalt perfectly similar to the basalt in the above-described ridge. The inner part of the iron mass contained no basalt, and as far as analysis has yet been able to discover, scarcely any traces of silica. In the neighbourhood of the smaller stones the sand and gravel were rusty with the effects of the weathering of the meteorites, yet their upper surface was usually pretty pure, but the under surface generally rusty. The larger stones were strongly polar-magnetic, so that the upper part of the stones attracted the north, the lower part the south pole of the magnetic needle.

[1] This Plate was inserted at p. 355, Geol. Mag. for August last, with Part II. of Prof. Nordenskiöld's paper.—Edit. Geol. Mag.

Within the area represented on the rough chart, not exceeding 50 square metres, the following blocks of meteoric iron were found by the Expedition of 1870:

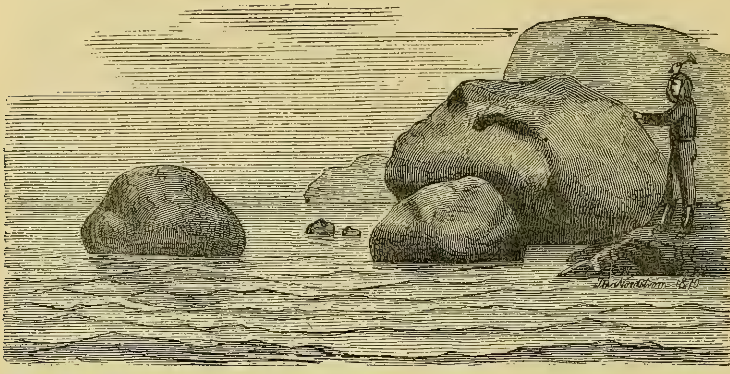


FIG. 14.—The three largest Meteoric Stones.[1] From a sketch made on the spot by Dr. Th. Nordstrom, A.D. 1870.

1. A stone, ovally rounded. Greatest diam.[2] 2 met. smallest 1·7 m. Probable weight[1]	...	21,000	Kilogr.
2. A nearly spherical stone. Greatest and least diam. 1·3 and 1·27 met. Probable weight[1]...	...	8,000	,,
3. A somewhat conical stone. Greatest and least diam.[2] 1·15 and 0·85 met. Probable weight[1]	...	7,000	,,
4. An oval stone (Plate XIX.–XX., Fig. 1) weighing ...	...	142	,,
5. A drop-shaped stone (Fig. 2) weighing	...	96	,,
6. A ditto ditto, now belonging to the British Museum	about	87	,,
7. A stone (Fig. 3) weighing	,,	54	,,
8. A stone (Fig. 4) weighing	...	81	,,
9. A stone (Fig. 5) weighing	about	42	,,
10. A stone (Fig. 6)	...	18	,,
11. A stone (Fig. 7)	...	24	,,
12. A stone which immediately after our arrival home fell to dust, originally weighing...	about	54	,,
13. A smaller stone weighing	...	6·4	,,
14. A ditto ditto	...	3·4	,,
15. A ditto ditto	...	2·5	,,
Several lenticular pieces of iron from the basalt vein, of 3–4 inches thick, weighing altogether	about	100	,,

The Ovifak iron is extremely crystalline and brittle, so that smaller pieces may be broken with a hammer, and, with the exception of the little bits of basalt on or near the surface, is not mixed with any silicates visible to the naked eye. The iron from the basalt ridge differs from the other by a rougher fracture and greater toughness. With the naked eye one can seldom discover any nodules of troilite or iron-sulphide. In the weathered detritus, on the other hand, a few black magnetic grains were found, with strongly reflecting facettes and octahedral surfaces, which on examination we found to be magnetite. When cut and polished, the different

[1] Brought to Europe by the Swedish Greenland Expedition of 1872, under command of Capt. Baron von Ober.

[2] Of the parts of the stones that lay above ground.

specimens varied very greatly; on some of them parts yellow as brass, of troilite were discernible, and the polished surface of the metal itself appeared, when the light fell on it in a certain direction, divided into rounded parts of different brilliancy and shades of colour. Other pieces seemed to form a perfectly homogeneous aggregate of crystal needles of carburetted nickel iron. The Widmanstädt's figures were visible after etching on some, but not all, of the specimens. *These were particularly distinct on the iron from the above-mentioned basalt ridge.* In general the iron was so hard that they would not undertake at the ironworks to saw through any of the larger balls, in consequence of which I know no more of the internal character of the meteoric iron than what I could ascertain from the specimens which fell to pieces.

(*To be concluded in our next.*)

NOTICES OF MEMOIRS.

Papers Read before the British Association, Brighton, 1872.

I.—On the Occurrence of Trunks of *Psaronius* in an Erect Position, resting on their original Bed, in Rocks of Devonian Age in the State of New York; with some Inferences regarding the Condition of Sea-bottom and Shore-line during the Deposition of the Strata.

By Professor James Hall, For. Memb. Geol. Soc., Lond.; of Albany, U.S.A.

AFTER a preliminary explanation of the general geological features and sequence of the formations in the State of New York, and a comparison of the thickness, condition, and nature of the sedimentary deposits along the Apallachian range, and in the plateaux of the west, Mr. Hall proceeded to the subject of the paper.

During the year 1870, some excavations made in Schoharie County, New York, in beds of fine sandstone referred at that time to the upper part of the Hamilton Group, but which probably belong to higher beds of the series, several trunks, which appeared to belong to Tree-ferns, were found in an upright position, with their bases resting in and upon a clay-bed, in which they appear to have originally grown. The clay-bed is filled with thin blackened bits of vegetable substance, which appear to belong to the large roots or bases, but no direct connexion has yet been shown. The strata above this, which enveloped the trunks to the height of two or three feet, were filled with fragments supposed to belong to these trunks and of other vegetation of the period. These trunks have been referred by Principal Dawson, of Montreal, to the genus *Psaronius;* and he has determined two or more species from the locality.

The points which I would call attention to are not those relating to the structure or relations of these plants, but to the fact that their presence indicates a point of comparatively dry land upon the eastern margin of the Devonian Sea. The position and relation of these trunks does not, I think, admit of a doubt that they have retained the position and locality in which they grew. No less than twelve of these trunks were found on two sides of an area less than sixty feet square. They were of various sizes, from less than six inches diameter in their smallest part to more than one foot in diameter at the same height above the base. Several of them have a diameter of more than two feet at the spreading base, and I have seen one specimen of fully three feet in diameter at its base.

The strata in the immediate neighbourhood contain few organic remains except plants, but the strata both below and above as well as on this horizon contain numerous fossil shells, Crustacea, etc. Going in a westerly direction, the sandy beds lose their coarseness, and the shales become finer, until we find deposits of calcareous mud. Receding from what I suppose to have been the ancient shore-line, the fossil shells are principally *Lamellibranchiata;* the *Brachiopoda* do not come in at all, or but in small degree, till we have travelled a considerable distance to the westward. Moreover, when we have so far left the shore-line that we can take satisfactory cognizance of the condition of the sediments, we find them made up of alternations of harder and softer beds—that the *Lamellibranchiata* are confined to the harder and coarser beds, and the *Brachiopoda* to the finer sediments, as a rule. Not only so, but sometimes the coarser beds are charged with a few species of particular genera, as of the *Aviculopecten,* while others are crowded with Modiola-like forms, with few *Aviculopecten*; while *Grammysia*, a genus which may perhaps belong to the *Unionidæ* has sometimes flourished abundantly to the almost entire exclusion of everything else.

Were we to make vertical sections at some points along a line extending westerly from the first points indicated, we should have something like what I have shown in the diagram where I have indicated the harder layers as much thicker than the softer ones, which are wedging out to the eastward. At another point, fifty or one hundred miles westward, we should find many of the harder beds wedging out in that direction, and the softer shales predominating in thickness, as shown in the diagram.

It so happens that we have a direct line of outcrop of more than three hundred miles from east to west, and while at the eastern end the sediments are coarse, and the prevailing fossils are *Lamellibranchiata,* with a few large Cephalopods, we have, at the western extremity, fine calcareous shales, with abundance of *Brachiopoda* and Corals, while *Lamellibranchiata* are rare. These formations in their greatest thickness are quite four thousand feet, and in their greatest attenuation about two thousand feet. Every layer has, of course, at one time been the sea-bed on which the animals have lived, and the final result has been the slow depression of this sea-bed to accommodate the gradually accumulating sediment. The belt of sediment in which the fossil trunks stand has again been submerged, and hundreds of feet of marine strata of the same age have accumulated above them.

Now the question arises whether this depression has been gradual and constant, or whether there have been intervals of depression, and again of elevation, making the movement which resulted in the great final depression one of oscillation. I have inferred the latter as the actual condition during all this period of the sedimentary accumulations. I am inclined to believe, moreover, that the alternation of coarser and finer beds may be due to such action, and that the pushing out of these coarser beds towards the westward, charged as they are by a littoral fauna, may be due to the elevation of the shore-line, and the consequent extension of such sediments. When again the shore-line recedes, from the gradual submergence and depression of this area below the sea-level, the finer sediments encroach upon the area before occupied by the coarser; the *Brachiopoda* succeed to the *Lamellibranchiata*, and we have the alternation of coarser and finer deposits, and the alternation of generations of essentially the same species, with now and then the coming in of new forms. Whether this view be tenable or not must depend on future continued and careful investigations. I had entertained this view from the alternation in the character of the sediments and the fossils. The discovery of this evidence of a shore-line, which afterwards became submerged, and again elevated, and extended westward at a later period, seems to offer some confirmation of the view.

II.—On the Tree-ferns of the Coal-measures, and their Affinities with Existing Forms.

By W. Carruthers, F.R.S.

Lindley and Hutton describe two species of Tree-ferns from the Coal-measures, both from the Bath Coal-field. I have been able to add eight species hitherto undescribed, chiefly through the assistance of J. M'Murtrie, Esq., of Radstock. These belong to three groups, which are remarkably distinguished by peculiarities in the structure of the stems. Two of the groups belong to living forms, while the third is extinct, being confined to Palæozoic formations. *Caulopteris* and *Tubicaulis* belong to the same type as the living Ferns which possess stems, including under this term the humble stems (falsely called rhizomes) of many of our British species, as well as the arborescent Ferns of warmer regions; and excluding the rhizomatous forms like *Pteris*, *Polypodium*, and *Hymenophyllum*. In all these stems we have a central medulla, surrounded by a continuous vascular cylinder penetrated regularly by meshes, from the margins of which the vascular bundle or bundles to the fronds are given off, and through which the parenchyma of the medulla is continuous with that of the stipes. In most Tree-ferns the medullary axis is larger, and the bases of the stipes decay down to the circumference of the stem; but in *Osmunda* the persistent bases of the stipes permanently clothe the small vascular cylinder which incloses a slender pith. To this latter form belongs the stipe with a dumb-bell-shaped vascular bundle, separate specimens of which I have obtained from the Coal-measures. These have been described, both on the Continent and in this country, under the name of *Zygopteris*, but they belong to Cotta's genus *Tubicaulis;* and they are very closely allied to a group of Fern stems which I have already placed together under the name of *Chelepteris.* The stem structure of the common Tree-fern is represented by the genus *Caulopteris,* of which I have six species of Carboniferous age.

The third and extinct group is represented by Corda's genus *Stemmatopteris,* only now known to be British, and by *Psaronius,* which is, however, not a separate generic form; it is based on the internal structure of the stems of which Corda's genus is the external aspect. The chief characters of *Psaronius* have been drawn from the structure of the aerial roots which invest the stem, from which indeed the generic designation was derived; while the structure of the stem itself has been overlooked. But this is really of the first importance, as will appear from the following description which I have been able to make from a finely-preserved specimen of an undescribed species in the British Museum, and from the figures of Cotta and Corda. The circumference of the stem was composed of a continuous envelope of indurated tissue; within this there were perpendicular tracts of vascular tissue never penetrated by any mesh. Between these tracts the leaves were given off in perpendicular series, the large single leaf bundles coming right out from the central parenchyma, where they existed as well-formed bundles, filling up more or less completely the medullary cavity. In one form (*Zippea*) the leaves are opposite, and the great proportion of the circumference of the stem is made up of the persistent and common vascular tissue: in others (species of *Psaronius*) the permanent elements of the stem consist of three, four, six, or more perpendicular tracts.

The first two groups are analogous in the arrangement of the parts of their stems to that which exists in the first year's growth of a dicotyledon. In both there is a parenchymatous medulla surrounded by a continuous vascular cylinder, which is perforated in regular manner by meshes for the passage out of the vascular elements of the appendages. The stems of the third group have a structure analogous to that which is found in the stems of monocotyledons, for in both we have the vascular bundles of the appendages existing in the parenchymatous axis, and passing out independently of any closed cylinder. The permanent elements of the circumference of the stems of *Psaronius,* are, however, without any analogue in the monocotyledonous stems.

There seems then good reason for establishing two groups of Ferns, with differences characteristic of their stems, comparable to those which distinguish the stems of monocotyledons from those of dicotyledons. But the caution I have always insisted on in dealing only with vegetative organs is specially required here, for I have discovered, I believe, the fruiting fronds of one species of this group of plants. With the Bath specimens of *Stemmatopteris insignis,* Corda, as well as with those found on the Continent, the fronds of *Pecopteris arborescens* are always associated. It is the only Fern found with some of the Bath specimens. It is also to be observed that the bases of the stipes correspond with the size of the leaf-scars on the stems. These facts are not absolutely sufficient for the correlation of the fronds with the stem, but they are the best evidence for this that we can expect in Fossil Botany short of actual organic union. Now the fruit of *Pecopteris arborescens* is so near to that of *Cyathea* that I can find no characters whereby they can be separated. Our classification based on the stems must of course yield to that derived from the organs of fructification, and our group of Ferns, instead of being made into a new order, as would be the case by some who publish on Fossil Botany, must be grouped with a tribe of recent *Polypodiaceæ*.

It may seem that this is a forced and arbitrary grouping together of plants that in some important characters so remarkably differ; and so it is undoubtedly to those who with rash confidence generalize on the systematic position of plants from stem structure alone. But what can such objectors say to the practice of placing in close proximity plants that are beyond question nearly related to each other in all essential characters, though some have caudices while others possess rhizomes? Yet these two forms of stems are more widely separated from each other than the extinct Palæozoic group is from the recent forms.

III.—On the Occurrence of a Remarkable Group of Graptolites in the Arenig Rocks of St. David's, South Wales.

By John Hopkinson, F.G.S., F.R.M.S.

In a series of black, iron-stained shales, about 1000 feet in thickness, which form the lowest beds of the Silurian rocks in the immediate vicinity of St. David's, the author noticed the occurrence of about twenty species of Graptolites, which, he considered, furnished conclusive evidence of the equivalency of these beds with the Quebec group of Canada, the Skiddaw slates of Cumberland, and the Arenig group of Shelve. From their stratigraphical position, and from the evidence afforded by the fossils they had previously yielded, these rocks had already been inferred to be of Arenig age.

The Graptolites were collected in the lower beds of the series at Ramsey Island and Whitesand Bay, by Messrs. Hicks, Homfray, Lightbody, Kirshaw, and the author, in the course of a few days they spent together at St. David's in July.

Of the true Graptolites, or *Rhabdophora*, the only genera of undoubted occurrence are *Didymograptus*, *Tetragraptus*, and *Phyllograptus*. *Didymograptus* is represented by five species, three of which—*D. extensus*, Hall; *D. patulus*, Hall; and *D. pennatulus*, Hall —are characteristic of the Quebec group and the Skiddaw slates, *D. patulus* also occurring in the Arenig rocks at Shelve; the other species are new. Of *Tetragraptus* but one species, *T. serra*, Brong., a Quebec and Skiddaw form, has been found. *Phyllograptus* also is only represented by a single species, which is new. There is also another new species—a very peculiar branching form referred provisionally to *Loganograptus*. The absence of any specimens undoubtedly referable to *Dichograptus* is remarkable, as this is a common Quebec genus. *Diplograptus* and *Climacograptus*, genera of very rare occurrence in the Quebec group, have not as yet been found here.

Of the allied forms, all the genera of the so-called dendroid graptolites, so characteristic of the Quebec group, are present in the St. David's beds. *Ptilograptus* is represented by two new species, and *Dendrograptus* by five species, three of which—*D. divergens*, Hall, *D. flexuosus*, Hall, and *D. striatus*, Hall—are at present only known to occur elsewhere in the Quebec group, the other two being new. *Callograptus* is also represented by five species, three—*C. elegans*, Hall, *C.* (?) *diffusus*, Hall, and *C. Salteri*, Hall—being Quebec forms, and two being new; and lastly, of *Dictyonema* but one species, which is new, has been found. Many obscure impressions referred to the genus *Retiolites* also occur, one species seeming to agree perfectly as far as its state of preservation allows of comparison with Prof. Hall's figures, with his *R. ensiformis* of the Quebec group. Another appears to be distinct from any species yet figured.

The Graptolites and their allies are now thus known to be represented in the Arenig rocks of St. David's by nine genera and about twenty-two species. Of the true Graptolites three genera—namely, *Tetragraptus*, *Loganograptus*, and *Phyllograptus*—are exclusively confined to the horizon of the Quebec and Skiddaw groups. The remaining genus, *Didymograptus*, is represented in higher rocks by but two species, *D. Murchisoni* and *D. serratulus*. The former occurs in the Lower Llandeilo, at Abereiddy Bay, near St. David's, and at Builth; and the latter in the Hudson River group (Caradoc) of New York. It has also been recorded from the Skiddaw slates. With these exceptions *Didymograptus* is exclusively an Arenig genus occurring in rocks of this age in Canada, Cumberland, and Shropshire. The four genera of dendroid Graptolites have a more extensive range, *Dictyonema* lasting from the Cambrian to the Devonian period, but until now they were only known to occur together and in any abundance in the Quebec group of Canada.

During, however, a recent visit of the Geologists' Association to Ludlow and the Longmynds, the author had found, at Shelve, in the lower part of the Arenig rocks, underlying the great mass of the Llandeilo, a Graptolite zone, in which these four genera are represented by species, some of which are identical with, and others nearly allied to, those in the St. David's beds and in the Quebec group of Canada; these beds, and also the Skiddaw slates of Cumberland, the equivalency of which with the Quebec group has already been shown by Prof. Nicholson, being therefore of Lower Arenig age.

IV.—Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire. New Series. Part I. 1871–72.

Mr. L. C. Miall read a paper on the Contortion of Rocks.[1] He exhibited photographs showing contorted Limestone Beds in Draughton Quarry, where solid layers of rock, a foot or two in thickness, have been bent into the figure of an inverted W.

[1] See Geol. Mag. for November, 1869; also Popular Science Review, January, 1872.

The angles are sharp, but unbroken. There were a few fossils in the Draughton Limestone, and these were distorted like the rest of the rock, which sufficiently disproves the notion that the rocks were in a soft state when the beds were disturbed.

Mr. Miall has made a series of experiments on Limestone Rocks, which prove that they are both elastic and plastic; and that sharp unbroken contortions indicate a molecular re-arrangement which has been produced by causes slow and long-continued in their action.

Mr. W. H. Dalton, of the Geological Survey of England, contributes an interesting paper on the Geology of Craven, referring more particularly to the rocks occurring within the basin of the Aire. He gives a general account of the Silurian Slates, Carboniferous Limestone, and Millstone Grit, pointing out the most instructive sections of each rock.

Mr. Miall read a short paper on the Formation of Anthracite, which is published in abstract; and another on the Structure of Ganoid Fishes, introductory to an account of the Ganoid Fishes of the Yorkshire Coal-field.

In the Minutes of proceedings there is an address by Mr. John Brigg, J.P., on the Geology of the neighbourhood of Keighley.

REVIEWS

I.—"SUR LA DIVISION DE L'ETAGE DE LA CRAIE BLANCHE DU HAINAUT EN QUATRE ASSISES." Par MM. F. L. CORNET et A. BRIART, ingenieurs civils. Extracted from vol. xxxv. of the "Mémoires couronnés et mémoires des savants étrangers." (Published by the Royal Academy of Sciences, etc., of Belgium, 1870.)

WHEN, some years ago, the authors of this paper made the description of the Cretaceous Rocks of Hainault the subject of a detailed memoir, they were unable to assign any divisions to the fifth and most important formation of the series—the White Chalk. Since then, however, renewed investigations on their part, aided by new sections which had not before been available, have led Messrs. Cornet and Briart to consider the White Chalk of Hainault as being divisible into four distinct members, the local character of which at the same time the present paper seems to establish.

In this part of Belgium the White Chalk rests upon the denuded surface of what is known there as "gris" by the miners, the "*Craie glauconifère*" of foreign geologists. Its upper limit is marked by the appearance of the Brownish Chalk of Ciply, which is regarded as the representative of the lowest of the Maestricht beds.

Immediately below this comes the uppermost of our authors' divisions of the White Chalk, to which they have given the name of *Craie de Spiennes.* It consists of White Chalk tinged with grey, rough to the touch, and with an almost gritty fracture. It is irregularly stratified in thick and generally unbroken beds. It abounds in large greyish-brown flints, disseminated and in continuous bands. The average thickness of this deposit is about 500 feet.

The *Craie de Spiennes* rests on the *Craie de Nouvelles*, the next division, the upper surface of which is much eroded, hardened, and perforated by lithophagous molluscs. Phosphatic nodules, and fragments of shells, echinoderms, sponges, etc., with Chalk débris, together make up a thick conglomerate, which forms the base of the former stratum.

The *Craie de Nouvelles* is the purest White Chalk of the entire mass, it is soft to the touch, and can be written with. It is irregularly stratified in thick and much-jointed beds. Very black flints are numerous throughout. Its thickness is about 66 feet.

The third member of the series, the *Craie d'Obourg*, underlies the last, but no exact point of juncture between them is apparently to be discovered. It is a greyish white soft Chalk, irregularly stratified in thin and much-fissured beds. Black flints are disseminated through it in places; but in some localities they are entirely absent. A conglomerate similar to that at the bottom of the *Craie de Spiennes* divides this mass into two unequal portions, each of which, the authors think, it may be necessary in time to raise to the rank of a division, in which case the upper one would preserve the name of *Craie d'Obourg*, and the lower would be known as the *Craie de Strépy*. The thickness of the whole reaches in the north of the district to 500 feet, in the south it is only 100 feet.

The fourth and last of these White Chalk divisions is the *Craie de St. Vaast*, which separates itself, it seems to us, more naturally than the foregoing *Craie d'Obourg* into two subdivisions. Of these the upper consists of soft White Chalk, not marly, irregularly bedded in thin layers, with numerous nodules of iron pyrites, and *without* flints. The lower one is less white than the last, is somewhat marly, is irregularly bedded in thick beds, and contains very numerous black and white flints. In the west the *Craie de St. Vaast* is 166 feet thick, but it thins considerably to the south where it is scarcely 60 feet.

The palæontological evidence on which the necessity of the new divisions must naturally chiefly depend will be seen by glancing at the accompanying table, which we have drawn up for the purpose, from MM. Cornet and Briart's lists of fossils.

Most of the fossils which are shown in the table to belong to the *Craie de Spiennes* only, are rare, and all of them, with the exception of *Ananchytes ovata*, and possibly *Nodosaria Zippei* and *Bulimina variabilis*, are to be found in the Brownish Chalk of Ciply, which, as we said before, is the lowest member of the Maestricht series. The stratigraphical evidence on the other hand leaves no doubt as to the propriety of separating the deposits in question.

Magas pumila, which is absent in the other members of the White Chalk, occurs in great abundance in the *Craie de Nouvelles*, of which it is characteristic.

Table showing the Distribution of Fossils in the White Chalk of Hainault.

	Craie de Spiennes.	Craie de Nouvelles.	Craie d'Obourg.	Craie de St. Vaast.
Baculites Faujasii, Lank.	x			
Belemnitella quadrata, d'Orb....			x	
B. mucronata, d'Orb.	x	x	x	
Ostrea flabelliformis, Nils.	x		x	
O. larva, Lank.	x			
O. vesicularis, Lank.	x	x	x	
O. sulcata, Blum			x	x
O. lateralis, Nils.		x	x	
Janira substriacostata, d'Orb....	x			
Terebratula carnea, Sow.	x	x	x	
T. Heberti, d'Orb.			x	
Rhynchonella subplicata, d'Orb.	x	x		
R. octoplicata, d'Orb.	x	x	x	
Terebratulina striata, Walk....	x		x	
Avicula cærulescens, Nils.	x			
Fissurirostra Pallisi, Woodw...	x			
Crania antiqua, Defr.............	x			
Pecten cretosus, Defr.			x	
Magas pumila, Sow.		x		
Nodosaria Zippei, Reuss.	x			
Inoceramus, large sp.		x		x
Bulimina variabilis, d'Orb. ...	x			
Cristellaria rotulata, d'Orb. ...	x			
Ananchytes ovata, Lank.........	x	x		
A. gibba, Lank.			x	
A. conoidea, Lank............. ..			x	
Cardiaster granulosus, Forbes...	x			
C. Heberti, Cott....................			x	
Large *Spongiæ*, etc................				x

It would be interesting to find Messrs. Cornet and Briart's divisions corroborated by observations elsewhere on the Continent.

4th September, 1872. G. A. L.

II.—The Geology of Illinois.

J. G. NORWOOD received the appointment of Geologist to the State of Illinois in 1851, with an annual appropriation of 3000 dollars. In 1853 this sum was increased to 5000. Dr. Norwood published two small pamphlet reports, amounting to 111 pages. In 1858 A. H. Worthen succeeded Dr. Norwood, and has worked continuously from that to the present time. Four volumes include the results of his labours, amounting to 1733 pages of imperial octavo and 101 lithographic plates, executed by the Western Engraving Company of Chicago. When two additional volumes shall have been issued, the Survey, according to the original plan of the present director, will be completed. The date of the first volume is 1866; that of the last, 1870. The gentlemen who have contributed to these volumes are: A. H. Worthen, Director; J. S. Newberry, L. Lesquereux, F. B. Meek, J. D. Whitney, J. V. Z. Blaney, Henry Engelmann, E. D. Cope, H. A. Prout, H. M. Bannister, H. C. Freeman, S. H. Scudder, F. H. Bradley, H. A. Green, J. G. Norwood.

These volumes sketch first the physical geography, and then the general geology of the State, describing each formation in turn, in the descending order. After this are essays upon the Lead Region, Coal Fields, and Plants, Origin of Prairies, etc., and a list of chemical analyses. All the fossils are fully described and well figured. The chief bulk of the volumes is made up of detailed descriptions of the special geology of fifty-five of the counties. In the Palæontological portion the description of the Coal-Measure Plants occupies 178 pages and 46 plates—256 species. Only one Reptile, a Batrachian, has been found. The Fishes are described upon 155 pages and 17 plates. The Invertebrates of the Carboniferous system occupy 401 pages and 26 plates—Mollusks and Crinoids being the most abundant. The other classes are Insects, Crustacea, Myriapods, Annulata, Echinodermata, Gasteropods, Lamellibranchiates, Cephalopods, Brachiopods, Polyzoa, and Sponges. The fossils from the Trenton to the Hamilton group are described upon 159 pages and 13 plates.

The following is the nomenclature of the formations given in the second volume, which is an improvement upon that issued earlier :

			Maximum Thickness in Feet.
	Post-Tertiary.	Modified Drift and Drift	150
	Tertiary.	Eocene ?	150
CARBONIFEROUS.	*Upper Carboniferous.*	Coal-Measures and Millstone Grit...	1000
	Lower or *Mountain Limestone.*	Chester Group	800
		St. Louis Beds	200
		Keokuk Group	150
		Burlington Group	200
		Kinderhook Group	150
DEVONIAN.		Genesee Slate	100
		Hamilton Beds	120
		Upper Helderberg Limestones	25
		Upper and Lower Oriskany Sandstones	240
SILURIAN.		Lower Helderberg Limestone	200
		Niagara Group	200
		Cincinnati Group	140
		Galena and Trenton Limestones	300
		St. Peter's Sandstone	150
		Calciferous Division	120 exposed.

Illinois contains 55,400 square miles, extending over five degrees and a half of latitude. The entire western border is the Mississippi River, and hence the general slope of the surface is south-westerly. The country is essentially a plain, with a few mounds about 1150 feet above the sea in the north-west part, which are elevated 200 to 250 feet above the general level or prairie. The strata show five lines or axes of disturbance—usually faulted—sometimes an anticlinal axis. The line of disturbance varies from W. 10° N. to N. 20° W. In one case the St. Peter's sandstone and Burlington limestone are made to face each other, the downthrow being nearly 1500 feet. The epoch of disturbance was Post-Carboniferous.

All the State is covered by the ice-drift, unless a "mountain chain," from 500 to 600 above the mouth of the Ohio River, limits it upon the south. A part of the N.W. area is included in

Prof. J. D. Whitney's "driftless region;"[1] but Mr. Worthen thinks he has found many transported pebbles within it, showing that the ice must have passed over it. The iceberg theory is adopted to explain the phenomena. M. Lesquereux presents in full his theory of the origin of prairies. He thinks they were originally bays or shallow portions of fresh-water lakes, which gradually changed into swamps with an abundant aquatic vegetation, and finally, by drainage, became considerably elevated, and from the plants, mullusks, and diatoms, a rich soil developed itself. The high rolling prairie results from the occurrence of a large number of swamps partially separated by sandy banks, and often comes from simple denudation. He thinks the aquatic origin is shown by the natural absence of trees.

The Carboniferous system in Illinois attains a maximum thickness of 2500 feet, and underlies three-fourths of the area of the State. The statements in respect to the number and succession of the Coal-beds and contiguous strata contained in the first two volumes are corrected in the first chapter of the third volume. It appears that the generalizations of M. Lesquereux[2] and others concerning the equivalency of Coal-beds in Pennsylvania, Kentucky, etc., are based upon an erroneous stratigraphy. The "Mahoning Sandstone" and "Anvil Rock" were supposed to represent horizons 350 feet apart, including eight beds of coal. But a careful examination by Messrs. Worthen and Lesquereux along the Illinois River for one hundred miles, in 1867, proves these two arenaceous bands to be identical with each other; and hence the beds of coal, at first referred to an age posterior to the Mahoning Sandstone, are now seen to be anterior to the epoch of its deposition. This change in the stratigraphical column must necessitate some modifications in the inferences formerly derived from it.

As now revised, the Illinois section shows ten beds of coal in a vertical thickness of 600 feet in the central and northern parts of the State. Six of these average from two and a half to six feet in thickness, and the others range from a few inches to two feet. The thickest beds are in the lower division of the measures. In addition to the ten seams just mentioned, Prof. Worthen speaks of several "local beds" of coal in the Millstone Grit. Permo-Carboniferous fossils are found in the upper part of the Coal-Measures of Illinois, showing that the whole of the series is present.

M. Lesquereux's position in respect to the identification of Coal-Measures is this: Beds of coal can be identified in different basins by the peculiar assemblages of plants found in connexion with them. For example, No. 2 of Illinois is characterized by the presence of leaves of *Lepidodendron*, and scarcely anything else. Its supposed equivalent in Pennsylvania, the "Mammoth Bed," is largely the same in character, carrying also the class of fruits represented by

[1] Geology of Wisconsin, by J. Hall and J. D. Whitney, 1862, p. 114.

[2] Geological Report of Kentucky (Owen), vol. iv., p. 331. Amer. Journ. Sci., ii. vol. xxx., p. 367.

Trigonocarpum, and species of *Sigillaria*. Several species of *Neuropteris*, most of the *Odontopteris*, and several of *Alethopteris*, are found only in connexion with this bed. *A. lonchitica* is said to be an unfailing indication of this horizon. Above this bed the Lycopodiaceous plants diminish in frequency, and the ferns are more important guides in determining the equivalency. Twelve or more horizons are distinguished by M. Lesquereux in the different basins. The theory is not affected by the error in stratigraphy just referred to; but it is not adopted by the best American palæophytologists.

III.—The Geology of the London Basin.

Memoirs of the Geological Survey of England and Wales, Vol. IV.—The Geology of the London Basin, Part I.—The Chalk and Eocene Beds of the Southern and Western Tracts. By William Whitaker, B.A., London. (Parts by H. W. Bristow, F.R.S., and T. M'K. Hughes, M.A.) 8vo. pp. 619. (London, 1872.)

The geology of the country around London has not been the subject of many elaborate memoirs; indeed, we may say that hitherto the only important works written on this subject were Mr. Prestwich's "Water-bearing Strata," his lectures delivered at Clapham on the "Ground beneath us," and a Memoir by Mr. Whitaker on the Geology of parts of Middlesex, Hertfordshire, etc., descriptive of the country embraced by Sheet 7 of the Geological Survey Map of England. We do not mean to hint that the geology has been neglected; such an idea is sufficiently refuted by reference to the volume before us: for Mr. Whitaker has collected and printed the titles of papers referring to the geology of the country he describes, numbering no less than 500. Most of these, however, refer only to portions of the country, and not the least arduous task for Mr. Whitaker must have been the preparation of this list, and the gleaning from the papers all facts relating to the subject he had in hand, for now-a-days, in writing even a short paper, the most difficult part is often to ascertain what observers have previously written upon the subject, so as to give due credit to them.

Mr. Whitaker, who is now, we understand, the senior field geologist on the Geological Survey of England, has personally surveyed a very large portion of the country described. It includes the whole of the counties of Hertford and Middlesex, and parts of Bedfordshire, Buckinghamshire, Essex, Hampshire, Kent, Oxfordshire, Surrey and Wiltshire.

The formations exposed in this area are the Bagshot Beds, London Clay, Lower London Tertiaries and Chalk. Their general nature is first noticed, and then their range, lithological character, and sections are described in detail. One chapter is devoted to the sands of doubtful age on the Chalk, originally classed with the Crag by Mr. Prestwich, and subsequently referred to the Eocene period by Mr. Whitaker and others. The concluding chapters are devoted to Disturbances, with a notice of the likelihood of there being an underground ridge of older rocks along the valley of the Thames; to Denudations, and to Economics and Springs.

In the Appendix there are accounts of 488 Well-borings, arranged according to counties. To these Mr. Whitaker has added many remarks of his own in regard to the classification of the beds passed through; and, together with accounts of 36 borings, they form a most valuable record of facts.

Other Appendices contain copious lists of fossils, minerals, etc.

The whole work—embracing as it does a minute account of the Chalk and Eocene Tertiaries of the London Basin—reflects great credit on the author for the amount of valuable matter contained in it, its admirable arrangement, and the facility of reference given by the indexes to authors and localities. There are numerous woodcuts illustrating the geological structure and features of the country. The page illustrations would have looked much better had they been printed on blank leaves; and both type and paper might well be of better quality.

We may mention that the parts contributed by Mr. Bristow are chiefly notes on the geology of Berks, Hants, and Essex, etc.; those by Mr. Hughes are on the geology of portions of Kent.

The various superficial deposits have been left for a second memoir, as they are as yet mapped in part only. This will complete the geology of the important area called the London Basin.

IV.—Records of the Geological Survey of India. Part II. May 1872.

MR. W. T. BLANFORD contributes some notes on the geological formations seen along the coasts of Biluchistan (commonly called Makran), and those of Persia from Karachi to the head of the Persian Gulf, with observations on some of the Gulf Islands. Three distinct systems of rocks are exposed in these localities, in descending order:—1. Littoral concrete (sub-recent); 2. Makran group (post-Nummulitic; 3. Hormuz salt formation (of unknown age).

The island of Hormuz is a most singular place. It is almost destitute of vegetation, and consists of a mass of low craggy hills, brilliantly coloured. Beds of volcanic origin, dolerites and trachytes, rock-salt, shales and sandy-beds, are found interstratified, all belonging apparently to the same series. The rocks are much disturbed; beds of salt and volcanic bands alike dip at high angles. There is no evidence to determine the age of these salt beds; but they are clearly older than the Makran group, for in the Island of Hanjam they crop out here and there beneath this group, which rests unconformably upon them.

The prevailing rock along the Makran coast is a pale grey clay, with bands of shelly limestone, calcareous grit and sandstone. It is occasionally intersected by veins of gypsum, and contains numerous marine fossils, many of which seem identical with species now existing along the coasts.

The mud volcanos of the Makran coast appear to consist of this clay formation, which, being mixed up with salt water, is ejected by means of gas, and dries into cones.

The Littoral concrete is an impure loose-textured limestone, abounding in shells, the majority, if not all, of which are identical with those now common on the coast. At Jashk, on the Persian coast of the Gulf of Oman, it is well developed, and forms a low cliff about 20 feet high. The chief geological interest attaching to this formation is derived from the evidence it affords of recent elevation of the land.

Mr. W. King gives an interesting narrative of a traverse of parts of the Kummummet and Hanamconda districts in the Nizam's dominions; a moderately elevated tract to the westward of the Godavery river. It is traversed by a path between Paluncha and Narsimpet, along which route Mr. King made his observations, for except around the few villages, up some side paths, or in dry watercourses, it is at present almost impossible to see anything of the country, owing to the prevalence of thin tree jungle and undergrowth. The formations met with included, in descending order, the Kamthi sandstones, the Barakar sandstones, with Coal-seams six and nine feet in thickness, and the Talchirs. The Coal-fields of Pakhal talook and Pangadi Vagu are briefly described.

Mr. W. T. Blanford furnishes a sketch of the geology of Orissa, a province which borders the coast between Calcutta and Masulipatam. He briefly describes the character of the formations met with, which include Blown Sand, Alluvium, Laterite, Katak or Atgarh sandstones, Mahadeva? or Panchet sandstones and grits, Damuda sandstones, shales, and coal, Talchir sandstones, shales, silt, and boulder bed, and Metamorphic or crystalline rocks.

Mr. King describes a new Coal-field in the south-eastern part of the Hydrabad (Deccan) territory. A small map is appended, showing the general outline of the field and the rocks surrounding it. The Coal-measures occupy about eight square miles in extent, but the field requires further examination by borings before much can be said about its richness. H. B. W.

V.—Report of the Geological Survey of New Hampshire. By C. H. Hitchcock, Ph.D. 8vo. (Nashua, 1871.)

PROFESSOR HITCHCOCK, the State Geologist, here presents his report on the operations of the Geological Survey in New Hampshire, during the year ending June 1st, 1871.

The most laborious field of research has been the White Mountains, comprising an almost unbroken forest, traversed only by the bridle paths and roads required for the ascent of Mount Washington by summer visitors. However, the Professor and his assistants, Mr. J. H. Huntington and others, lived up in the mountains in extempore camps, and visited the most inaccessible peaks and ravines, until all had been explored.

Very many speculations have been entertained respecting the rocks, elevation and age of Mount Washington, and the associated mountains, a brief account of which is given in the report. The structure of Mount Washington seems to be that of an inverted anticlinal. The rocks composing the area are believed to belong to two great systems, the Gneissic or White Mountain series, and the Andalusite Rocks or Coos group, which overlies the other. Both are presumably Eozoic.

With the approval of the State authorities, the Survey undertook to investigate the meteorology of Mount Washington, the highest point of land within the State, and about 5000 feet in elevation. Tables of observations are given, and a short report is furnished by Mr. S. A. Nelson.

A more detailed account of the work of the Survey will be hereafter published.

VI.—Lecture on Water, delivered before the American Institute of the City of New York, in the Academy of Music. By Charles F. Chandler, Ph.D., Professor of Analytical and Applied Chemistry, School of Mines, Columbia College. (Albany: The Argus Company.)

DR. CHANDLER'S discourse, while aiming at providing popular instruction, contains much that will interest the scientific reader. In the first portion of his lecture he treats of the constituents of pure water, and the history of their discovery; then a description of spring water and its impurities leads him to speak of artesian wells. At Louisville, Ky., there is one 2,086 feet in depth, yielding water with a temperature of 82° F., and so highly charged with chemical compounds that it is prized for its medicinal properties. At Charleston, S.C., there is a well 1,250 feet deep of similar mineral water. On page 14 there is a statement which requires correction. The author, when speaking of the precious metals dissolved by sea-water, states that their presence was detected by their being taken up by some "iron nails in the keel of the vessel," and their per-centage was exceedingly small. The Doctor possibly had in his mind the analyses that were made of the copper and Muntz metal from the hulls of vessels plying between ports along the west coast of South America made by Field, who found that an appreciable amount of silver was extracted from the sea-water of that region during a few years' exposure. In describing the brine-wells of the United States, he enables us to realize their importance, by telling us that the brine pumped from the artesian wells at Syracuse, State of New York, from a depth of from four to five hundred feet, has produced nine millions of bushels of salt in a single season. The celebrated springs of Saratoga and Ballston rise along the line of a fault in the rock of Saratoga county. They consist, to begin with the uppermost, of the Hudson river and Utica shales and slates, the Trenton limestone, a siliceous limestone, the Potsdam sandstone, and the Laurentian rocks of unknown thickness. The Laurentian hills being impervious convey their surface waters to the exposed edges of the Potsdam beds, whence the soluble matter is derived. One spring, on the margin of Kayaderosseras Creek, contains 1,200 grains of mineral matter per gallon; others a notable amount of lithia, for example: the Pavilion spring at Saratoga 9·48 grains of bicarbonate, the Hathorn spring 11·44 grains, and the Conde Dentonian artesian well at Ballston 10·51 grains. A very remarkable acid water comes to the surface at Oak Orchard, State of New York; of the 211 grains of mineral matter found in it, no less than 133·3 are sulphuric acid, 32·2 sulphate of iron, and 13·7 sulphate of lime. Hardly less curious is the water of the borax lakes of California, containing 535 grains of borate per gallon. Several pages on the characteristics of a good drinking water contain much that is very entertaining and of practical value, and though we should like to quote some portion of it on the connexion apparently traced between the spread of goitre and cretinism and the impregnation of the waters of the districts where these maladies prevail, with lime and magnesian salts, we must content ourselves by concluding this brief notice of a useful pamphlet with a fact or two regarding the water supply of New York. The Croton water is brought to the city by an aqueduct forty-five miles in length,—the average quantity supplied daily being 65,000,000 gallons. The three reservoirs at present in use having proved insufficient during long continued dry weather,[1] an additional one of colossal magnitude, covering an area of 303 acres, is now in process of completion; this will hold a quantity sufficient to supply the city with its present population for fifty-five days. The Croton water is of remarkable purity, containing only 6·87 grains of solid constituents to the gallon, of which but 0·67 of a grain is organic matter. When will London be supplied with such water?

VII.—Town Geology. By the Rev. Charles Kingsley, F.L.S., F.G.S., Canon of Chester. 8vo. pp. 239. (London: Strahan and Co., 1872.)

THIS little work consists of six chapters which were originally given in the form of lectures to the members of the Cheshire Natural History Society. Written in a simple homely style, they are intelligible to the most unscientific reader, and indeed they are intended rather to excite an interest in geology in the unlearned, to give them some idea of scientific reasoning, than to furnish any new facts to the student. Chapter 1, entitled "The soil of the Field," deals with modern denudation. Chapter 2, on "The Pebbles of the Street," treats of glaciers and glacial deposits, and changes of climate. Chapter 3, on "The Stones in the Wall," contains an account of the Triassic rocks, and also, by means of an imaginary rail-

[1] We may direct attention, as bearing somewhat on this question, to the protest entered by Mr. Verplank Colvin in the twenty-fourth annual report of the New York State Museum of Natural History, against any further destruction of the forests of the Adirondack wilderness. He calls to mind the fact that year by year the water supply of the principal rivers of New York and her canals experiences notable diminution, and sees in this the result of the clearing of the slopes of the high mountains of Central New York, and looks forward to the time when, if these operations are not checked, the Hudson will cease to be navigable more than half-way to Albany, and other streams will suffer in proportion. A *précis* of his arguments is given in *Harper's Weekly* for August 10th, 1872, page 623.

way journey to London, Canon Kingsley gives a brief notice of the succeeding rocks up to the Bagshot Sand. Chapter 4 is on "The Coal in the Fire," and explains the origin of coal. Chapter 5, on "The Lime in the Mortar," treats of Limestones and Coral-reefs. And Chapter 6, on "The Slates on the Roof," deals with the older rocks and volcanoes; and here we may state that the notion of mountain chains being due mainly to contraction, needs correction on the part of the author, who remarks that "the loftiest mountain chains are nothing but tiny wrinkles." The new edition of Jukes's Manual will give the latest information on this subject. Otherwise we may congratulate the author on the easy and interesting, and yet accurate manner in which he has illustrated "Town Geology."

CORRESPONDENCE.

"A CRY FROM THE LAND OF EGYPT."

Sir,—While the *Source* of the Nile has been honoured by the concentrated attention of Geographers, it has been my own fate to suffer the cruellest mortifications—it pains me to have to add—"in the house of my friend," the Geologists.

The controversy on the origin of the Wealden, between the advocates of the Lake- and Delta-theory respectively, has been prolonged in its duration, and often doubtful in its results; but some have supposed this may be only a necessary consequence of the slowness of the methods of inductive research. Fortunately, however, the author of a paper in the last number of the Quarterly Journal of the Geological Society has discovered a summary way of settling this long-vexed question; discarding the old and tedious methods of inquiry, he has succeeded, by the application of a few very simple crucial tests, in so triumphantly establishing the Lake-theory, as actually to reduce it to an *axiom*, and to employ it as the basis of a number of highly curious speculations.

It is impossible to exaggerate the striking novelty of the views of Mr. Meyer on the subject of estuarine deposits. I quote the paragraph in which he enumerates the crucial characters which, found in the Wealden, demonstrate the impossibility of that formation having originated in a delta.

"The exceedingly quiet deposition of much of the sedimentary strata, the almost total absence of shingle, the prevalence, both numerically and specifically, of such species of mollusca as abound in quiet waters, the comparative absence throughout the greater portion of the series of broken shells such as always abound in tidal rivers, and, I believe I may say also, the total absence of drift wood perforated by mollusca in either the Purbeck or Wealden strata, all seem to me to point to the same conclusion—namely, to the accumulation of such strata beneath the waters of a wide but shallow lake, etc."—*Quart. Journ. Geol. Soc.*, vol. xxviii., p. 243.

In order to appreciate the high originality of these ideas, it is only necessary to reflect on the opinions which have hitherto prevailed on the subject. Earlier writers, whether travellers, physical geographers or geologists, so far from anticipating the interesting discoveries of Mr. Meyer, would almost appear to have conspired to perpetuate the vulgar errors current upon the subject. Thus, in treating of existing deltas, they have actually represented their waters as ramifying in innumerable sluggish streams, or collecting into vast swamps, stagnant lagoons, and shallow lakes, often of great size; with remarkable unanimity they have dwelt on the extreme fineness of the sediments in these waters, and the slowness with which they were deposited; but, strange to say, the existence of the characteristic "*shingle*" they appear to have altogether overlooked. Further, they have described some of the grandest deltas in the world as formed in *tideless* seas. Unfortunately, too, the disseminators of these erroneous views have been aided by the naturalists, who have declared that the existing boring-molluscs are all *marine;* and they have been abetted by the palæontologists, who have described the ancient allies of these boring-molluscs as occurring in such strata as the London Clay and the "Lower Greensand," and never *in any freshwater beds at all,* whether of estuarine or lacustrine origin.

Where the error has been so universal, it may seem invidious to particularize individual authors; but I cannot refrain from pointing out what appears to have been almost infatuation, with respect to this subject, on the part of the author of "The Geological Observer." Not content with describing in great detail the muddy character and quiet mode of deposition of the delta sediments, Sir Henry De la Beche has actually stated that 400 miles from its mouth the waters of the Ganges can no longer move coarse gravel!—and so far is he from perceiving the necessary connexion between tides and deltas, that he even represents the action of the former as altogether inimical to the formation of the latter. So great, indeed, was his misapprehension on the subject, that he has actually founded the division into chapters of part of his great work on the (of course, erroneous) supposition that deltas are only formed in "tideless seas," or in those where, owing to the action of local causes, the tide is neutralized. I need not point out how uniformly these errors have been adopted by writers of less authority on physical geography and geology.

Of course, by the interesting discoveries to which I have alluded, large portions of our existing geological treatises are rendered obsolete, and will require to be re-written; but great revolutions (even of opinion) are seldom effected without causing some inconvenience to individuals. Perhaps, therefore, I have little right to complain of my own case, which is, nevertheless, one of some hardship.

Formed of deposits which all observers, from Herodotus to Horner, have agreed to call "mud" and not "shingle,"—by streams which, meandering over the level plains of Lower Egypt, and forming such lakes as Bourlos, Menzaleh, and Mareotis, finally empty themselves into the *tideless* Mediterranean,—streams in whose waters, moreover, no naturalist has ever yet succeeded in detecting a single boring-mollusc,—I stand convicted by Mr. Meyer as a gross impostor, in bearing the title by which I have so long been recognized, that of

"The *Delta* of the Nile."

THE

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ORIGINAL ARTICLES.

I.—On the Forms of Valleys and Lake-basins in Norway.

By J. M. Wilson, M.A., F.G.S.,
Mathematical Master of Rugby School.

THE general object of this paper is to draw attention to the apparently close connexion between the configuration of the surface in a glaciated country like Norway, and the disposition of the principal planes of division of the rocks, whether these planes be caused by stratification, cleavage or joints.

I do not know how far this connexion has been already noticed by others, or if it has been noticed at all. My attention was first called to it in a visit to Glencoe some years ago, where, however, the connexion is not always to be traced, in consequence partly of changes subsequent to glaciation. And in a short visit to Norway, during this summer, in which I visited the Hardanger and Sogne Fiords and their neighbourhood, the same connexion was again forced on my attention. I therefore offer these remarks to the attention of geologists, that they may verify how far the connexion that I speak of is general and important as throwing light on the origin of the details of the configuration of the surface of the earth.

Norway presents many advantages to a student of this branch of geology. Its physical features are striking; and they are continually repeated till they become almost monotonous, and so whatever lesson they have to teach is driven home by sheer iteration. The glaciation of the country down to the sea-level has been very recent, and ice marks and striations are so common as after a time scarcely to attract attention; subsequent weathering has only here and there, when the rocks are soft, begun to obliterate the effects of the ice-sheet and glaciers; there is often no accumulation of soil and turf on the rocks to hide their structure; in the summer at any rate there is no snow; and the torrents and waterfalls have been acting for so short a time, geologically speaking, that their effect on the landscape can be discerned at a glance, and is generally quite insignificant. We have therefore in Norway a country in which the effect of ice may be studied with pre-eminent advantages.

Moreover, the nature of the rocks in the neighbourhood of Bergen and the Hardanger and Sogne Fiords is well adapted for observations of this kind; the rocks are principally of mica slate, clay slate, and gneiss, with divisional planes very strongly marked, and in blocks often of very large size. The rocks are in general very hard, and compact; the slaty structure not being predominant.

The valleys in this part of Norway are merely the continuation of the fiords, and have a very uniform character. Their direction is generally nearly straight on the whole; they are narrow, however, and the minor curves are sufficient to prevent a view from one end of the valley to the other; their sides are steep, often precipitous, and terminate at a level, singularly uniform in each district, of about 2500 to 3000 feet. At this level the slope changes and becomes much more gradual, forming the sœter (or chalet) level, on which cows and goats pasture in the summer, inhabited by lemming and ryper, and covered by heath and bilberry, birch and willow. From this sœter level rise the gently sloping snow-fields, as of the Folgefond, or the peaks and mountain chains, as of the Horungerne, which are thus totally invisible from the valleys. Even the Horungerne mountains, whose outline is comparable to that of the Bernese Alps for variety and grandeur, and several of whose summits are over 8000 feet in height, are completely hidden by the edge of the sœter level from all the valleys and fiords that surround them. Over the edge of this sœter-plain the water falls into the deep valleys sometimes in great cascades like the Vöring Fos or Mörke Fos, sometimes in Staubbachs too numerous to have received names.

At the end of each fiord the levels of old sea-beaches are almost always to be seen; when these are passed there is generally a lake, moraine-dammed, and at its head other terraces. Then the valley narrows, and winds on, slowly rising, sometimes opening out into a few acres which form a small farm, and sometimes flanked by precipices and steep slopes of huge blocks of stone terminating in the river at the bottom. Sometimes masses of *roches moutonnées* form a buttress projecting from one side, or a central mound, or a barrier extending completely across the valley. At the curves of the valleys the glaciation is very evident.

Now the fact that struck me again and again in walking up these valleys was this: that the disposition of the principal divisional planes of the rocks altered with the windings of the valleys; so that in general the surface of these planes determined the slope of the hills, and the direction of the valley at the spot. Wherever you look across a valley, you have a plane facing you, or making a small angle with the surface, dipping inward *up* the valley. These divisional planes are not in general, certainly not always, planes of stratification; they might be called planes of cleavage, if it is remembered that the rock is often in vast blocks, and not in the least slaty; and are intersected by minor divisional planes or joints. In ignorance what the best name for them is, I have called them the principal divisional planes. It was therefore forced upon me that the forms of these valleys were determined by the disposition and flexures of the principal divisional planes of the rocks. Moreover the forms and position of the masses of *roches moutonnées* are similarly dependent on the disposition of these planes. Where there is a ridge of *roches moutonnées* across a valley, I almost always found that the joints were wide apart, and the dip of the planes was up the valley. In other words, the blocks of rock were so placed that the moving ice had no advantageous hold on them, and so scraped over them instead of tearing them out from their bed. It became perfectly plain that ice acts in this way, detaching a block and pushing it down the valley, and thus can break up and remove large masses of rocks, while the direct effect of attrition is very small.

Hence the forms of the sides and bed of the valleys seem to depend on these divisional planes; they have been worked down until they offer a minimum resistance to the passage of the ice, which will slide by a smooth divisional plane, or gradually wear away the edges of masses that dip backward towards the direction from which the ice is moving, but will wrench out a block which presents a face in the direction of the ice stream.

It may be illustrated, as my friend Mr. Sidgwick suggested to me in one of these valleys, by sheets of cork, a material similarly jointed. In certain positions your hand will slide over them and produce no effect; but in others, that is when the faces of the blocks meet the hand, the blocks are torn up from the surface, and leave the blocks below in precisely the same disadvantageous position, so that the process will be continued. Or it may be illustrated by a pack of cards. If they are thrown down so as to form a long stream—preparatory to cutting for partners—your hand will glide over them in one direction without displacing them; in the other direction it catches them and pulls them out of place.

In one or two cases I found the dip of the planes down the valley; but these were at points where the slope was so steep that the dip was up the ice stream though down the valley.

It is impossible not to form the hypothesis that here may be found the origin of lake-basins. For if we admit that ice in the form of a glacier has vast pushing power, even though it has very slight eroding power, it seems plain that wherever the divisional planes are so bent as to form a series of concentric basins in the path of a glacier, it will scoop out the blocks in following those divisional planes and form a basin. If an existing lake-basin, for example, were filled with brick-shaped masses, and a glacier moved down upon it, one cannot doubt that it would have sufficient power, gradually to push these masses before it, and raise them up the opposite slope. Unquestionably this action is in accordance with what we see ice doing, and does not make those demands on our belief of the eroding power of ice which are required by the ordinary erosion theory. Moreover, several small lake-basins exist in Norway, of which the form appears to be determined by the divisional planes. It will not be difficult to put this hypothesis to the test of facts, and thus to ascertain whether the condition for a lake-basin is the requisite curvature in divisional planes lying in the path of a glacier. I may add one or two other remarks on points of geological interest.

The glacier near Odde on the Hardanger Fiord, called the Buerbrae, is worth special attention. It is easily visited in a day from Odde, which is accessible by steamer in a day from Bergen. It is an entirely new glacier, there having been no glacier in the valley fifty years ago, as I was assured. It has advanced

2000 yards in twenty years, and during the present year has advanced 70 yards. It is now (by aneroid) 1155 feet above the sea. The steep slope of ice terminates in a very small moraine, a yard or two wide, supplied partly by small stones falling from the surface, and partly from the ploughing effect of the snout of the glacier. Masses of fresh turf, with flowers still in bloom, are thrown up in this moraine as the inexorable mass pushes on. It is now ploughing through the sweet pastures belonging to a farm. Within a few yards of the glacier, are to be found wild roses and foxgloves, ladies-mantle and holly fern, and a score of meadow flowers, with ripe raspberries, and strawberries and blackberries. By ascending the valley by the side of the glacier, or on the steep face of the cliffs, one may study, under the most advantageous circumstances possible, the mode of action of a glacier. There, at about 700 feet above the lowest point of the glacier, on the north side, the joints in the rock run in such a way as to expose the blocks to be torn out of their beds; and there I saw a huge mass, detached by only a foot or two from its place, but on its way down the valley. There is also the peculiarity in this glacier of a large waterfall in the middle of it, at about 3500 feet above the sea, falling from under a wall of ice topping precipitous glaciated rocks, over which masses of ice occasionally fall.

The glaciers in the Horungerne mountains, at any rate on the eastern and northern faces, are retiring at present. One of those on the eastern side, visible from the hills about two hours' walk beyond the Mörke Fos, showed most plainly the successive moraines that it had left as it had paused in its retreat. Another glacier visible from the same point is the most symmetrical as regards its form and its crevasses that I remember to have seen. The crevasses form regular parabolic curves with the vertices pointing up the valley.

About a mile from Eide on the Hardanger Fiord, on the post-road to Vossevangen, is a cliff of mica slate. The lower half of it was protected from weathering by a slope of stones, an old moraine, till within the last few years, when the stones were removed to make the road. Hence there is exhibited a splendid contrast between the weathered and unweathered parts of the cliff. The lower part is smooth and striated, though the material is here soft and crumbly; and the upper part is already much broken up. Young trees are growing in its crevices, blocks have fallen from it, turf is beginning to form on ledges in it, and it has lost every trace of glaciation in detail. The fact is of course commonplace enough, but the contrast is so striking in this particular instance that it may be pardonable to mention it.

In conclusion, I will repeat that for structural geology there is no place like Norway; and it is as a working hypothesis for observations—and for this purpose almost any hypothesis is better than none—that I commend, especially to geological tourists in Norway, these observations and speculations as to the forms of valleys and the origin of lake-basins.

GEOLOGICAL SECTION OF ARTESIAN WELLS, VENICE PREPARED BY MM DEGOUSÉE & LAURENT, C.E. PARIS FOR A TYLOR'S PAPER.

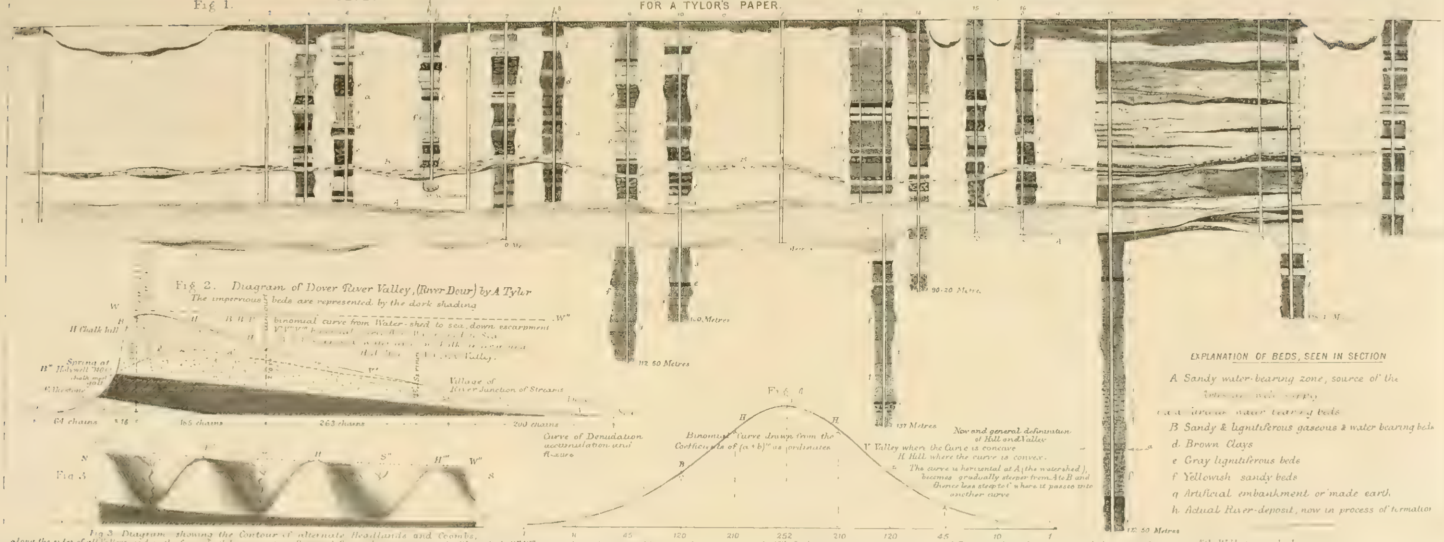


Fig 3. Diagram showing the Contour of alternate Headlands and Coombs, along the sides of all Valleys and on the faces of all Escarpments in Binomial Curves. In proportion as the Watershed W''W''' is curved in plan and in elevation the proportions of S'H' S''H'' &c vary, often forming a chain of Hills in which the evidence of the original alternate arrangement of Headland & Coomb is more or less distinct. The symmetrical form is modified by the River flowing from V' to V'' winding among headlands and altering the bases of the binomial curves and affecting the stability of the upper parts

To illustrate Mr Alfred Tylor's paper on the Formation of Deltas

II.—On the Formation of Deltas: and on the Evidence and Cause of Great Changes in the Sea-Level during the Glacial Period.

By Alfred Tylor, F.G.S.

(PLATE XI.)

Part II.—Continued from page 399.

It would be the safer plan, in considering the remarkable Gravel and Crag deposits which characterize so distinctly the Quaternary Period, to infer the size of rivers, amount of rainfall, and elevation of tides from the deposits themselves. Further acquaintance with meteorological phenomena may find a fitting explanation of the difficulties we meet with in explaining the position of the gravel at such heights above our present streams, and fresh-water, alternating with marine clay, and sands at such depths below the sea-level.

Delta of the Po.—The diagram, Pl. XI., Fig. 1, represents the different strata passed through in making 20 borings for water in the Delta of the River Po, near Venice. These extend from St. Servolo to Ghetto Nuovo, a distance of about 6 miles. The well at Casa de Dio reaches a depth of 572 feet. That of St. Maria Formosa 452 feet. M. Laurent, of Paris, the experienced well-borer, who is well acquainted also with geology, kindly made the drawing for me many years since, a copy of which I now use as a diagram. Of course the only points accurately determined are those in the 18 borings. The two great water-bearing beds have been traced throughout the 18 borings, and are represented as continuous in the diagram marked A. and B. They can only supply water equal to the quantity of rain on their outcrop.

The clays, lignitiferous sandy pebble and shell beds, are represented by different colours; also the wells from which gases escape are distinguished on the drawing Fig. 1. At St. Leonardo, No. 17, the lignitiferous beds occupy nearly one-third of the first 190 feet of strata passed through. The great water-bearing sands are 40 feet thick at the A. point.

The lignites sometimes succeed clays, sometimes sand, and are not continuous, they are therefore entirely distinct in stratification from the true coals of the Carboniferous formation, which are stratified continuously and usually repose upon clay. It is however interesting to observe the horizontal development of the water-bearing sands of a Delta, which may compare with similar horizontal bands in the Coal-measures. The evidence offered by these two remarkable beds of sand is that there was a marked change in the amount of denudation in the area drained by the Po, or in the material thrown back on to that part of the Delta by the sea, arising from a change in the position of the margin of the Delta (when these sands were deposited), as well as the coarse material indicating a greater rainfall.

The surface of the soil at Venice is 5 feet, on an average, above high-water mark in the Adriatic.

The mineral character of the first and last stratum perforated at Casa de Dio are remarkably alike, although separated by 500 feet of strata. The upper bed contains fragments of human industry and marine shells exclusively. In descending from the surface the marine shells become mixed with freshwater species. Sands are most frequent in the lower beds, and contain lignite, consisting of broken pieces of vegetable origin, distributed through the mass of sand like some beds in the Hastings Wealden, where subsequent denudation enables the relations of clay beds to sands to be well seen (see A. Tylor, on the Wealden, Q. J. Geol. Soc., 1862, vol. xviii., p. 250).

In the middle and upper series the lignite occurs in veins or threads, and in beds alternating with sands and clays. The lower beds are very micaceous, but there are only traces of mica in the upper series.

The beds in this Delta may be said to be horizontal, as in a distance of six miles there is no sensible difference of level. In the Wealden there are numerous flexures.[1]

At St. Maria Formosa, No. 8, there are 5 water-bearing beds, one within 8 feet of the surface. At St. Leonardo the spring of water is 80 feet from the surface. There are great variations in the water-level of springs and wells in most deltas.

The course of the river Po from its source at Monte Viso, 801 feet above the mean level of the sea, to the mouth at Maestro, has been drawn by Mr. Beardmore (Man. Hydro., plate xiii.), who also gives sections of the tributaries.

For a distance of 150 miles between Chyvasso and Cremona the line represented by the level of the bank of the Po closely coincides with the parabolic curve; at no part is there a greater error than 5 feet in a course of 150 miles.

I mention these circumstances, as Deltas and alluvial formations are described as planes, while their surface really is a close approximation, I believe, to a true parabolic curve. It is sufficient here to record the fact that the approximate level of the bank of the Po at any point can be ascertained, if three points are given in the manner above stated.

M. Ch. Laurent writes to me, Oct. 31, 1868:—"The wells of Venice, are, as you know, in the enormous Delta formed by the Po, the Adige, the Tagliamento, and the Brenta, filling up a gulf. The alternations of sand met with often present debris of marine shells, *Cardium*, etc. The lignites and lignitiferous clays, as far as I could observe, in the well sunk in the Island of San Servolo and at the Madonna del Orto, contained fresh-water debris and terrestrial remains. In this debris I have seen *Succinea*, *Pupa*, *Helix*, and even in the lignites in the well sunk in the Place St. Marc, an elytra, perfectly preserved, of an insect (*Buprestis*). This insect was unfortunately destroyed by contact with the air. There is in these deposits an oscillation or alternation (*balancement*) between the marine products and the fresh-water products. It is altogether what takes place now at the surface in modern deposits."

Flexures[2] arising from the original or (latest) uneven upheaval of

[1] *Not fractures* exclusively (see Quart. Journ., p. 251, 1862, by the author). The author thinks these flexures are in consequence of uneven upheaval, often in binomial curves, along and at right angles to a curved axis, elevated most in the Pluvial Period at Crowboro', and before denudation commenced; flexures, longitudinal and transverse, aided by side streams, principally guide the Wealden watercourses and rivers in their remarkable course; this I shall prove by measured sections hereafter. (See Figs. 5 and 6.) —A. T., Nov. 1868.

[2] Flexures in binomial curves may be seen in all Geological books, although they are not described as such by those who have drawn them.

the tract situated within the water-shed, consisting of unequally inclined, unequally hard, and of unequally pervious strata, start and determine the subsequent direction of every watercourse, and all main, tributary, and pluvial denudation[1] in the valleys of the Po, Weald, Thames, and all other rivers. Thus tributaries and side streams, flowing off the soft Oolites near Schaffhausen, from their inclination against the stream flowing from very high ground, oppose and repel the Rhine, while others further on, inclining towards the stream, attract and assist it to pierce the much harder rocks[2] between Bingen and Bonn.[3] Thus the hard rocks sometimes are denuded, while soft ones out of the track escape.

M. Lombardini, in his work "Changes in the Hydraulic Conditions of the Po"[4] (1852, Milan), removes some misconception about the position of the bed of the river Po, which have not only passed current for many years, but have been quoted as typical conditions of rivers. M. Lombardini shows that the flood high-water mark of 1839 was only 5 feet above the ancient natural bank, and was 3 feet actually below the surface of the ancient embankment of the Po. The prolongation of the Po, as erroneously calculated by M. de Prony, was from A.D. 1200 to A.D. 1600, at the rate of 815 feet per annum. from A.D. 1600 to the present century, at the rate of 227 feet per annum. M. Lombardini shows that the rate of progress of the Delta from A.D. 1600 to the present day is only one-fifth greater than formerly, and that increase is owing to the levées, which have raised the level of the river 3 feet 3 inches.

There appears to be no foundation whatever, according to Lombardini, for the statements made about the condition of the river Po, for Lombardini proves by reference to flood-gates that the extreme low-water surface of the river has not changed sensibly in two centuries; also that at Stellata, 16 miles above Ferrara, the surface of the river at that point could not have been elevated since that day by the prolongation of the Po. There are no lumps of clay in the Po, raised by subsidence elsewhere, as in the Mississippi. The drainage of a lake, or melting of snow, or denudation, or deposition, disturb the existing equilibrium of the crust of the earth, but gravity must have always assisted the force producing subsidence, and opposed that producing elevation. If the mass of freshwater strata from the earliest period has always borne the same proportion to marine strata above the sea-level that it does now, and that the mass of earth above the sea-level has always borne to the mass of the sea, then extra heat must have been obtained from above and below, or from chemical action,[5] to produce elevatory and depressing force exactly sufficient to do the required work, less the effective force of gravity

[1] Denudation is work done to produce stability in strata to bear their load under the new physical conditions established.

[2] The author has a very interesting case of a river piercing a rock near Istrad Vellte, South Wales, which he will shortly describe, showing an actual case of denudation.

[3] See, "Remarks on Denudation," by the Author, read May, 1868, p. 71, vol. xxv., Quart. Journ. All tributaries adjust their bottom levels in relation to the main stream. They cannot cut down their beds when the main stream blocks their water.

[4] Humphreys and Abbot, page 414.

[5] See Sir H. Davy.

employed in favour of subsidence, and producing elevation in balance; for instance, the conversion of a dry valley into a lake must tend to lower the earth's crust by its extra weight, tending to produce subsidence at one point and elevation at another. Any delta deposit would tend to produce subsidence. The depression of the Channel must have lowered a much larger mass, apart from volcanic energy, than the Wealden elevation raised. In the opinion of the author, all elevations are uneven and sudden. The elevation of the Alps in the Miocene period must have accompanied or been the consequence of a much larger movement of depression; probably at the time a Miocene island or continent (near Plato's Atlantis) in the Atlantic was suddenly depressed. E. Forbes thought the position of the great floating masses of sea-weed marked the site of this ancient land. A subsidence of solid matter in one part may displace fluid or gas, on Sir H. Davy's theory, and produce an elevation of solid matter to an equivalent height elsewhere; but it cannot produce a corresponding elevation elsewhere (as part of the force is expended without producing motion), except where there is a fluid, or the equivalent of a fluid (as in the Delta of the Mississippi), to communicate movement without loss of energy, or below the surface of the solid crust where matter may be fluid.

In concluding my remarks upon the Delta of the River Po, it is only necessary to repeat that it is shown in the diagram Fig. 1, by the strata, A. and B., that there are two principal beds which are always water-bearing, one between the limits of 145 and 181 feet, and the other at about 200 feet. The upper sand bed, B., is so full of carburetted hydrogen gas, that in applying a light to the mouth of some of the wells the gas first detonates and then continues burning with a constant flame. The lower sand bed contains less gas, but is always full of water, which flows with great regularity.

The writer exhibited at the Geological Society a drawing by Mr. Jenkins of some of the Eocene *Cyrena* beds, with plants, etc., which prove that at Dulwich a deposit like that of the Delta beds of the Po existed in Eocene times.

Delta of the Mississippi.—A somewhat similar bed of sand exists in the Delta of the Mississippi, near New Orleans, at a depth of 60 feet from the surface. This has been tapped in many parts of New Orleans for the carburetted hydrogen gas it contains. Iron tubes, three or four inches in diameter, are forced down 60 feet, and the gas is sufficiently good for burning. I will now give an abstract of the description which has been published, of the section of a well, by Dr. Bendict.

The well, commenced in New Orleans in 1854, was only continued to a depth of about 630 feet. There are 36 well-marked alternations of clay and sands; 4 lignitiferous beds, some with rootlets, and the lowest at 150 feet from the surface containing a sound cedar log striated with thin plates of siliceous matter. There are 6 shell-beds in different parts of the series of marine and fresh water-beds? making a total of 14 feet. The lowest, No. 54, was 543 feet from the surface. The 18 beds of clay make a total thickness of 266 feet. The lowest of these is 36 feet thick, and is No. 55 in the series. No. 53, clay, was found to be 63 feet thick. No. 48, 29 feet thick, very pure clay. No. 42, 32 feet thick, leaden blue clay effervesced with acid. No. 22 clay is described as identical with No. 19, and effervesced with acid. No. 19, blue clay, with amber-coloured masses, each containing a yellow pebble. The remaining 12 clay-beds only amount to 205 feet in thickness, or an average of 17 feet each.

As in the Delta of the Po, so in the Mississippi Delta, the lower beds are the most sandy. Messrs. Humphreys and Abbot[1] give the dimensions of the Delta as follows:—

The area of the tract of alluvial land from Cape Girardeau to the head of the assumed Delta, as given by previous writers, is too great. By careful measurements upon the most authentic maps it is as follows:—

	SQUARE MILES.
The St. Francis bottom	6,900
The Yazoo bottom	7,110
The Tentas bottom . . , ...	4,440
Small Swamps in the east bank, from Cairo to Baton Rouge	1,000
	19,450

The area now drained by the Mississippi and its tributaries is estimated at 2,455,350 square miles.[2]

From Humphreys and Abbot's report we learn that the Mississippi water is never charged with matter in suspension up to the quantity the water could hold. At high-water, both in 1857 and 1858, the river held little more sediment per cubic foot than at dead low-water, when the soundings of the Survey proved that the river made no deposit in its channel. The caving in of the banks when the river is falling temporarily affects the amount of sediment in the river.

SLOPE OF THE MISSISSIPPI RIVER.[3]

	Miles from head of passes.	High water above gulf.		Resulting fall per mile in water surface.		Highwater.
		ft.	inch.		Miles.	feet.
				Gulf by S. W. pass	17	0·165
				Gulf by N. E. pass	16	0·175
				Gulf by Passe l'Outre	15	0.187
				Gulf by S. pass	14	0·200
Head of Passes of Mississippi in Gulf of Mexico	0	2	8	... ...	20	0·115
Fort St. Philip ...	20	5	1	... ...	84	0·121
Carrolton	104	15	3	... ...	72	0·146
Donaldsonville ...	176	25	8	... ...	52	0·156
Baton Rouge ...	228	33	9	... ...	71	0·220
Red River Landing	299	49	5	... ...	62	0·226
Natchez	361	66	0	... ...	269	0·309
Vicksburg	470			... ...	225	0·320
Games Landing ...	630	149	0			
Napoleon	672					
Memphis	855	221	0	... ...	204	0·436
Columbus	1059	310	0	... ...	21	0·571
Cairo	1080	322	0	... ...	173	0·497
St. Louis	1253	408	0			

[1] Report on the Mississippi. U.S. War Department, 1864, p. 434.
[2] Op. cit., p. 93. [3] Page 113, Humphreys and Abbot, 1864.

The heights are not determined from a trigonometrical survey at points above Natchez, and are therefore only approximate. They are derived from the information given by different railway engineers, whose lines have crossed the Mississippi.

By drawing a parabola, the curve will pass near all the chief intermediate points. There is a deviation of twenty-two feet at Red River Landing, and of three feet at St. Louis. The fall of the Mississippi is six inches per mile at Cairo. This is the case of greatest error south of Cairo. At many points the parabolic curve corresponds exactly with the surface of the alluvium, so that by knowing the distance from any point, you could find the height; or, by knowing the height, you could tell the distance precisely from Cairo or New Orleans. It will be seen that a similar law holds good for the navigable part of other rivers.

The heights at some points are probably not correct within several feet, as they are not based upon a trigonometrical survey.

In a paper published in 1853, the author considered the probability of the rainfall all over the globe being many times the present average throughout the world, on the evidence of the fineness of the present river sediment compared with the coarseness of the old alluvial and gravel deposits.

The average maximum depth of the Mississippi between the Ohio and the head of passes in the Gulf of Mexico, determined from the average of forty-five cross sections, is 104 feet.

The highest maximum recorded is 180 feet, and the lowest maximum is 71 feet. The greatest width of river is 7,800 feet, and smallest recorded 1900 feet. The average area of the cross section is 197,250 square feet. The average width is 3,505 feet; so that according to these figures the average depth must be 56½ feet from the Ohio to the sea, although it is not printed in the report.

Yearly Amount of Rain in the Valley of the Mississippi.

	Square Miles.	Downfall of rain in inches.	Cubic feet of rain.
Delta	12,300	60·9	1,700,000,000
Red River	97,000	39·0	8,800,000,000
Arkansas and White Rivers	189,000	29·0	13,000,000,000
St. Francis	1,000	41·1	1,100,000,000
Missouri	518,000	20·9	25,200,000,000
Up Mississippi	169,000	35·2	13,800,000,000
Ohio	214,000	41·5	20,700,000,000
Yazoo	13,850	46·3	1,500,000,000
Small	32,400	47·8	3,600,000,000
			89,400,000,000

In extreme low-water years, as 1839 and 1835, the discharge of water is only about 11,000,000,000 of cubic feet. In ordinary years it is 19,500,000,000 cubic feet.

In great flood years, as 1823, 1828, 1844, 1849, 1858, it is supposed to average about 27,000,000,000 cubic feet. The discharge is now

$19\frac{1}{2}$, and compared with the rainfall at $89\frac{1}{2}$, is about as 1 to $4\frac{1}{2}$. This difference arises from the re-evaporation of the rainfall several times before it reaches the Gulf.

In 1851 the mean proportion of sediment to water for the whole year was $\frac{1}{1808}$, the maximum was $\frac{1}{681}$.

Professor Riddell's last experiment was $\frac{1}{1158}$ by weight.

By Mr. Meade's experiments, page 149, it appears that, at Carrolton, sand is always moving along the bottom of the Mississippi. An engineer who has resided in a plantation near Fort St. Philip, below New Orleans, describes the newly-deposited material to be sand, and not mud, and that it is observed to move along the bottom of the river at a point within thirty miles of the Gulf of Mexico. At Carrolton the mean temperature of the air in 1851 was 67°·6, the river water being 63°·9. The mean temperature of the Mississippi increases 3° between Memphis and Carrolton.

Taking the present rainfall at 41·5 in., and that in the Pluvial Period at 300 in. (p. 9, Quart. Journ., vol. xxv.), the ratio is 7·23 to 1, or sevenfold. If the solid matter in suspension was seven times coarser than at present, on the average, we have a new measure of the power of denudation and of the extent of rainfall in the Pluvial Period, for the velocity and quantity of water flowing at the same slope must be in a definite proportion to the coarseness of the materials carried by the water, and *vice versa*. If 300 inches of rain fell in large storms, there might have been floods carrying 125 times the present quantity of water, an amount deduced by the author from observing the form and dimensions of the Quaternary deposits in the Valley of the Aire, Yorkshire.[1] The width, depth, and coarseness of the fluviatile deposits of the Mississippi are, in proportion to an average of sevenfold the rainfall and nearly twofold the velocity.

On the 4th of October, 1858, the current was 1·72 feet per second, and the water held in suspension 138 grains of solid matter per cubic foot of water, or 22·13 grains per gallon. In the Pluvial Period the author supposes the water held in suspension 160 grains per gallon in $\frac{1}{437}$ of the weight of water.

Messrs. Humphreys and Abbot state (p. 399, *op. cit.*) that at New Orleans, thirty-nine feet below the surface, the marine[2] strata begin, or those belonging to an earlier geological age than the present, or, at least, before the material brought down by the Mississippi river as now existing began to accumulate in this locality.

I have written to Dr. Bendict, at New Orleans, for the names of the shells, but have as yet received no answer. Sir C. Lyell records the occurrence of an estuarine shell[3] near Lake Pontchartrain at a great depth, and very near New Orleans, where, on the contrary, Humphreys and Abbot describe marine shells. This requires expanation, as well as many of their other opinions as to the age of the clay imme-

[1] See p. 63, Quart. Journ., 1869.

[2] The probability of the Mississippi Delta being partly marine was suggested by A. T., p. 272, Phil. Mag., 1853:—"If the further examination of the Delta of the Mississippi shows marine or fluvio-marine strata," etc.

[3] *Gnathodon cuneatus*, a common brackish-water bivalve.

diately below the modern alluvium. Sir C. Lyell's account of the stratification of the Delta appears much more precise than that of Messrs. Humphreys and Abbot, who seem to wish to bring the formation of the whole of the alluvium of the Mississippi within a period of 4,400 years. As far as I can ascertain, this view of the Delta, 280 miles long, 70 miles wide, having been formed in 4,400 years, is entirely contrary to their own evidence.

Mr. Sidell (p. 10, Appendix A, *op. cit.*) writes respecting the lumps which rise on the river and sea-bottom near the passes of the Mississippi into the Gulf of Mexico. These lumps have a peculiar appearance. In entering the mouth of the river they may be taken for rocks, from the steepness of their sides, their compactness, and the appearance of stratification produced by cracks. In some cases they rise eight or ten feet, nearly perpendicularly, and at one place there is a mound in the shape of a truncated cone, ascertained to be at least eighteen feet high. It is nearly inaccessible through the marsh or flat that surrounds it.

The material of the lumps is a very fine clay; it decrepitates with heat. On many of these lumps are found springs of salt water. The spring issues through a well-defined crater as firm on the sides as a chimney, generally of about six inches diameter. There is an ebullition of the water of the spring at considerable intervals, and inflammable gas constantly escapes from some of them. This is probably light carburetted hydrogen gas. The salt water stands in these springs two or three feet higher than the level of fresh water of the surrounding river. Some of these lumps form islands several acres in extent, they are only found in the immediate vicinity of the Gulf, and they form the nucleus for shoals. They are reduced by violent rain, and are supposed to be raised by pressure of gas formed below the surface by the decomposition of vegetable matter, the hollow being filled up with mud. The surface of many lumps is covered with white pure salt, evaporated from the deposit of the springs (see p. 16, Appendix A).

The origin of these lumps is thought to be chemical rather than mechanical, and they evidently differ from mounds formed in marsh ground which have been raised by tipping ballast near it.

It is recorded that during the Survey of the Mississippi bar a lump two feet high was discovered in the Channel which had arisen within two or three hours.

On the more probable hypothesis that 3 parts in 100 of the whole material denuded are deposited on the Delta, and not removed again, and that the remaining 97 parts are carried out to sea before being deposited, then the extension of the whole Delta, 55 miles (by means of fluviatile deposit alone), into the Gulf of Mexico would require sufficient time to effect the denudation of over 2,455,250 square miles of surface, averaging 100 feet.

I calculated the present rate of denudation of this area in 1853, and my figures have been recently adopted by Mr. Croll. I found that the denudation was going on at the rate of 1 foot in 10,000 years in the above area, and at this rate we should require 10,000 × 100, or above 1,000,000 years for a denudation of 100 feet under present conditions, or 138,393 years on the hypothesis of a Pluvial Period.

If the whole area of the Mississippi basin was 600 feet higher on the average above the sea than it is now, and glacial and pluvial conditions exerted in greater force (indicated by the coarseness 7·3 times of the deposits), the rate of annual denudation would also be much increased and the time shortened in proportion.

It certainly appears by the diagram, made from soundings in the Gulf of Mexico and River Mississippi, that modern marine strata, 600 feet or more in thickness, have been deposited on the bottom of the Gulf of Mexico, extending over some thousand square miles. I say modern, for it must be identical in age with the Mississippi Delta deposit.

According to Humphreys and Abbot, about one-eighth of a cubic mile of detritus is annually transported to the Gulf of Mexico by the Mississippi. They have calculated the rate of progress seaward of the river, and extension of the Delta, as if the Delta had been recently prolonged all along its outer edge, instead of at a mere point. Sir C. Lyell has also drawn attention to the narrowness of the present deposit near the passes. It is clear that only a very narrow tongue of land has been pushed out into the gulf by the river. The river would have to change its course from time to time in order to push out similar tongues of land round the Delta, which is a sector of a circle ; and it would take evidently above 30 times as long to add 50 miles all round the Delta as it has taken to make the single strip of land, which contains the present river channel.

There is also great probability that when the river changed its course, the previous accumulation might be removed by the sea and redeposited near the new channel.

Messrs. Humphreys and Abbot only consider the superficial deposit as belonging to the river, and speak of this exclusively as alluvium, and as totally distinct from the beds of clay and thick sands which occur below the alluvium, and which alluvium proper they describe in different parts of the basin as from 20 feet to 60 feet thick at the maximum. There seems as much distinction in mineral character between the alluvium of the present river and the ancient deposits below it, as there is between the peat and alluvium of England and the gravels below them.[1] This indicates, in the opinion of the author, as great a change in the rainfall and climate in America as in England, at a period not long antecedent to the true historical period, in all probability in the proportion of 20 inches to 300 inches, or even a still higher ratio.

Sir C. Lyell explains the occurrence of decayed wood and of freshwater and estuarine shells as far below the surface of Deltas as 380 feet, in the following manner (page 247, vol. ii. second visit, U.S.) :—"These appearances may readily be accounted for, by assuming there was a gradual subsidence of the ground for ages, which was as constantly raised by the accession of fluviatile sediment, so as to prevent any intrusion of the sea. Occasionally there were

[1] M. Belgrand has, since the date on which this paper was written, 1868, confirmed this view in his great work on the Seine.

pauses in the downward movement when trees grew on the soil, and vegetable matter of some thickness had time to accumulate."[1]

In the latter part of this paper I shall suggest that the appearances indicated in the Deltas of large rivers, of subsidence of the land, may possibly be caused by a great fall in the sea-level during the Glacial Period by contraction of the sea by cold and by abstraction of water for conversion into ice and snow, to be deposited on the colder regions of the earth. The subsequent elevation of the sea-level, and encroachment of the sea on the land, may account for the shallow soundings off the Delta of the Mississippi in the Gulf of Mexico. These indicate a large recent deposit there, and this may have been formed during the fall in the sea-level, and then have been submerged by the restoration of the sea-level to its original point near the close of the Glacial Period.

Delta of the Ganges.—From the description of Lieut. R. Baird Smith, p. 4, Proceedings Geological Society, 1846, we learn that between the 382 feet and 423 feet level below Calcutta in the Delta was found gravel with bones of lizard and turtles associated with large rolled pebbles of quartz, felspar, limestone, and indurated clay.

At the 380 feet level there occurred two feet of blue calcareous clay, with many fragments of shells. At 382 feet this was succeeded by a layer of dark clay filled with decayed wood, ferruginous sands, and thin beds of clay from 208 feet to 380 feet From 183 feet to 308 feet, indurated ferruginous clay. At 175 feet a coarse friable quartzose conglomerate occurs, composed of pebbles of different sizes cemented together by clay. From 130 feet to 150 feet argillaceous marl; from 75 feet to 120 feet, variegated clay. At 65 feet to 75 feet, green siliceous clay. At 55 feet to 65 feet, clay. At 30 feet to 50 feet, large portions of peat with decaying fragments of trees were found. These were identified with existing species still living on the spot. The clay was met with at ten feet from the surface. If we apply the hypothesis of a fall in the sea-level, we have a *vera causa* for producing a state of physical circumstances under which pebbles could be transported from the high land in the interior of India to an immense distance. During an average denudation of 100 feet over a large district, some points of land may have been reduced 1,000 feet in height. If some of the mountains were 1,000 feet higher, and the sea 600 feet lower, we should have an ancient Ganges river of immense carrying power and dimensions, such as might bring down large pebbles and boulders, where now the present Ganges can only bring down mud.[2]

Between Futhguhr, near Hurdwar (428 feet high), and the sea the distance is 1,219 miles. Testing this section by a parabolic curve, the deviation is five feet at Cawnpoor.

[1] The author suggested the Delta being marine in the Phil. Mag. p. 272, and also the probability of the rainfall and denudation being many times greater than at present. Phil. Mag. 1853.

[2] Mr. T. Login, Quart. Journ., vol. xxviii., has added some valuable information as to the Ganges deposits.

By knowing the direct distance from any point, you can determine the height of any other spot correctly, that is within six feet, or, by knowing the height, you can find the distance within a few miles between any points.

The Volga.—For a great part of its course of 2,000 miles long, this parabolic curve truly represents the contour of the surface of the alluvial plain and Delta of the Volga. The Volga rises in a lake 630 feet above the level of the Caspian Sea.

Mr. Eyth, who has superintended irrigation works in Egypt, and is well acquainted practically with the Delta of the Nile, considers that the surface of the Delta is a mathematically exact curve, and thinks its straightness at the Delta portion, where he has particularly observed it, makes it more like an hyperbola than the parabola I suggested.

The engineers in the Mississippi Report treat that river as a plain, but their own table of the changes in level per mile in passing from Balize to St. Louis proves that it is a curve. See *antè* page 489.

The flatness of the Nile cannot be greater than that of the Mississippi, which, according to Mr. Meade (Appendix A. xix. Mississippi Report), is $1\frac{3}{4}$ feet in the last twelve miles of its course, or $1\frac{3}{4}$ inches to the mile on the average.

We have clear indications that these stratified gravels were deposited under very different meteorological and physical conditions from any we now meet with. We have found evidence of littoral conditions in Delta deposits and on the sea-bottom down to the 100 fathom line, wherever examinations have been made; these are only in scattered localities, and the evidence is only obtained by boring and dredging.

Such littoral deposits as we have been considering are small indeed compared with the littoral deposits to be seen in the Pacific Ocean formed by coral zoophytes over a tract of 5,000 miles in length. It is stated that many species of these zoophytes would be destroyed by immersion under water only a few fathoms deep. In ordinary cases reef-building polyps do not flourish at greater depths than 20 to 30 fathoms. (Page 86, Darwin's Geological Observations.) Exposure to air for a few hours at the surface of the sea is also fatal to their existence. Mr. Darwin writes, "With respect to subsidence, I have shown in the last chapter that we cannot expect to obtain in countries inhabited by semi-civilized races demonstrative proofs of a movement which invariably tends to conceal its own evidence." (Page 127, Darwin's Geological Observations, 1851.) It was from this difficulty of absolutely proving subsidences of sea-bottoms that Mr. Darwin considered he had exhausted every demonstrable course before he adopted the theory of subsidence to explain the formation of the coral islands of the Pacific. At page 147 he speaks of subsidences as "the one alternative."

In the South Sea Islands every stranded root of a tree was examined for the hard stones attached to it.[1] It is therefore

[1] According to the accounts of early travellers.

possible that pieces of rock, with living coral attached to sea-weed or wood, might be thus floated from one island to another, etc. Also the fundamental rocks, on which the coral reefs are attached, may have been of such a friable character as not to be able to stand above the level of the sea. Some such conditions may have prevailed in the Carboniferous epoch. We have no modern instance of such rocks, neither have we evidence in former periods of any coral deposit of the form and dimensions of the Pacific Islands. Modern peat is not a type of Coal. Geologists assume too much when they rely on the analogy of modern conditions being a complete key to the knowledge of former conditions on the earth. Nor is the reverse true.

There are fourteen cases of elevation recorded by Mr. Darwin varying from 20 to 30 feet above the sea-level to a maximum of 300 feet. Very few of these instances have been examined by any geologist. There is, therefore, no means of measuring the thickness of the upheaved coral deposits by sections beyond 300 feet, as there are no known cases of elevation beyond that limit of thickness.

Mr. Darwin writes, p. 146, Geological Observations, 1851. In the 4th chapter the growing powers of the reef-constructing polyps were discussed, and it was shown that they cannot flourish beyond a very limited depth. "In accordance with this limit there is no difficulty respecting the foundations on which fringing reefs are based; whereas with barrier reefs and atolls there is a great apparent difficulty on this head: in barrier reefs, from the improbability of the rock of the coast, or of banks of sediment, extending in every instance so far seaward within the required depth; and in atolls from the immensity of the spaces over which they were interspersed, and the apparent necessity for believing that they are all supported on mountain summits, which, although rising very near to the surface level of the sea, in no one instance emerge above it. To escape this most improbable admission, which implies the existence of submarine chains of mountains of almost the same height, extending over areas of many thousand square miles, there is but one alternative, namely, the prolonged subsidence of the foundations on which the atolls were primarily based together, with the upward growth of the reef-constructing corals. On this view every difficulty vanishes. Fringing reefs are thus converted into barrier reefs, and barrier reefs, when encircling islands, are thus converted into atolls the instant the last pinnacle of land sinks beneath the surface of the ocean."

The maximum depth of the coral lagoons is 60 fathoms, either in lagoons or between the shore and barrier reefs. In dredging outside coral reefs you have a sandy bottom, and not a coral bottom, at greater depths than 60 fathoms, and not often deeper than 20 or 30 fathoms. Then comes a very steep descent to very great depths, almost close to the coral islands.

Mr. Darwin and Sir H. T. De la Beche differ on the important point of there being no existing case of a sea-bottom of large extent sufficiently shallow to form a base for coralline zoophytes to work on. The following extract is most clear on this point:—

De la Beche writes, Geological Observations, p. 227, 1851—"As regards inequalities of sea-bottom, if the Great Bank of Newfoundland were in coral regions, and were elevated from its present relative level, so that its broad platform with its common depth of 40 to 50 fathoms were raised about 20 fathoms, by which coral reefs making germs could fix and develope themselves under fitting conditions, we should have an area of between 35,000 to 40,000 square miles, around the irregular margin of which there would be conditions for an extended border of coral reefs: the sea round the margin would often be suddenly deep. Soundings up to 149 fathoms are found close to the south-eastern side of the bank."

Supposing that the sea-bottom in the Pacific was originally of similar heights to Sir H. T. De la Beche's case of the Newfoundland Banks, then applying our hypothesis of the fall of 600 feet in the sea-level during the Glacial Period, supposing that period to have continued 138,000 years, we should have a sufficient period and also a gradual change of conditions and level of sea so as to be most favourable to the growth of coral banks.

As far as the limit of 600 feet—which is a greater depth than we are certain coral ever reaches below the surface of the sea—the theory of a fall in the sea-level appears to explain the difficulties of the subject, as well as that of gradual subsidence and elevation. Having now hastily reviewed some of the more important littoral deposits that might have been formed in the last 138,000 (?) years, and having found that there are no greater difficulties presented by the hypothesis of a change in the sea-level than occurs with the theory of subsidence of the sea-bottom, I will add a few remarks on the growing importance of the Glacial Period geographically considered.

With regard to the importance of the Glacial Period, Prof. Agassiz long since wrote:—"The British Islands, Sweden, Norway and Russia, Germany and France, the mountainous regions of the Tyrol and Switzerland, down to the happy fields of Italy, together with the Continent of Northern Asia, formed undoubtedly but one ice-field, whose southern limits investigation has not yet determined. The polar ice, which at the present day covers the miserable regions of Spitzbergen, Greenland, and Siberia, extended far into the temperate zones of both hemispheres, leaving probably but a broader or narrower belt around the equator, upon which there were constantly developed aqueous vapours which again condensed at the poles."

Time has not modified Agassiz's views of the importance of ice action, for he writes, p. 424, Journey in Brazil, 1868, after applying the theory of ice action to the formation of immense beds of drift in the valley of the Amazon, near the Equator, and the level of the sea:—"I am aware that this suggestion will appear extravagant. But is it after all so improbable, that when Central Europe was covered with ice thousands of feet thick—when the glaciers of Great Britain ploughed into the sea, and when those of the Swiss mountains had ten times their present altitude, and Northern Italy was filled with ice, and these frozen masses extended into Northern Africa; when a sheet of ice reaching nearly to the summit of Mount Washington, in the White Mountains (that is having a thickness of nearly 6000 feet), moved over the Continent of North America—is it so improbable that in this epoch of universal cold, the valley of the Amazon also had its glacier, poured down into it from the accumulations of snow in the Cordillera, and swollen laterally by the tributary glaciers descending from the table lands of Brazil?"

After this, Oscar Fraas's account of the remains of true glacier moraines on Mount Sinai, at a height of 700 feet only above the sea-level, does not seem so astounding as it really is.

Prof. Forbes writes of the glacial sea (p. 382, vol. i., Mem. Geol. Survey, 1843):—"An arctic sea inhabited by a limited and uniform fauna" (I presume Prof. Forbes intended to restrict the uniformity of the fauna to the zones of equal depth and temperature), "extended from the then western coasts of Siberia into the heart of North America, and southwards in Europe to the parallel of the Severn, and in America to that of the Ohio."

Prof. W. W. Smyth quotes an estimate of the temperature of the summer months, of the space now occupied by London, in the Glacial Period at 126° F. The author calculates that a decrease of 30° Fahr. in the mean temperature of the ocean would reduce the level of the sea 150 ft., while a deposit of snow or ice 1500 feet thick in an area of land one-tenth of that of the sea would also reduce the level of the sea 150 feet.

APPENDIX.

Note on the theory of a "Pluvial Period," p. 486.—[Mr. Prestwich in all his writings has attributed the valley gravels to floods caused by sudden melting of ice and snow under the maximum rainfall now met with in similar localities. There is no trace in his works of the idea of a Pluvial Period until 1872. The average rainfall in some parts of Great Britain being five times that falling in other parts, Mr. Prestwich has taken the higher figure for his British Gravel Period, just as Sir C. Lyell refers to the greatest eruption in modern times as a guage for all previous ones that have occurred. Both Mr. Prestwich and Sir C. Lyell consider present meteorological conditions as the test for those that previously existed. The writer, on the contrary, infers the amount of rain causing the Quaternary deposits from the coarseness and position of the gravel deposits themselves. Both plans may be useful in endeavouring to ascertain the truth about a very difficult question. Mr. Prestwich has, in his address of 1872, quoted M. Belgrand, 1870, for a 20 or 25-fold rainfall in the Quaternary Period, and given his qualified assent to the idea of a Wet or Pluvial Period; but he has not referred either to A. Tylor's paper in 1853, in which he first proposed the hypothesis of many times the present average rainfall and deposit, or to page 63, vol. xxv. Quart. Journ., where A. Tylor calculated the volume of water in the Gravel Period as 125 times that at the present time. At page 9, same vol., A. Tylor writes of 300 inches of rain at the sea-level in the Quaternary Period. In the text of the paper, read November, 1868, and now published in the GEOLOGICAL MAGAZINE, this subject is treated at greater length. The term Pluvial Period was first used, page 105, vol. xxiv. Quart. Journ., 1868, in a paper by the writer, and the term has been since used by Prof. T. R. Jones, Prof. Dawson, and other writers. Mr. Prestwich never contemplated any general excess of rainfall above what is known at the present time, and therefore differed from the author, who made an hypothesis of a general rainfall on the globe many times more than at present in 1852. Mr. Prestwich opposed every view brought forward by the author in 1852, and also in 1868 and 1869.]—Aug. 1872, A. T.

Note on "Elevations," pp. 397 and 399.—[The marine shells at Moel Tryfaen and at Coalbrook Dale at such different levels indicate a very unequal elevation of part of England and Wales. The hypothesis of a change of sea-level accounts for a very even change of position of land and water over large areas, totally differing from anything that could be produced by elevations or subsidences, which are always accompanied by flexures and uneven movement of strata.]—A. T. Aug. 1872.

Note on pp. 393 and 492.—[The author has sent full particulars of the slope of the Mississippi, Ganges, Rhine, and Indus, to the Institution of Civil Engineers, Feb., 1872.]

Note on page 397.—[The author cannot find any evidence whatever as to the real character of the rocks below the surface of the Pacific in the works of any geologist. It is quite an assumption, unsupported by any evidence, to state that they are formed of recent coral to considerable depths. It seems probable that reef-building coral zoophytes must have lived at much greater depths than has been supposed, or they could not have passed from one island to another, as they must have done to spread over such a mass of islands separated by seas of enormous depth. The low temperature of our atmosphere and of the Atlantic at great depths is probably a survival or a result of the Glacial period. In a warm period coral zoophytes might live at very great depths, as they are said to do in the Red Sea now. The supposition of immense continuous periods of subsidence, without a counterbalancing elevation, is against the principle of the conservation of force. There is no direct evidence of EVEN elevation or EVEN subsidence over any area of more than a few miles recorded in the writings of geologists. The strata are always curved where there is direct evidence of elevation or subsidence.]—A.T. Aug. 1872.

Note on page 495.—[It requires further examination. In the Nile valley there are now no constantly flowing tributaries, but there are immense side valleys, which must have been full of water in the Pluvial Period.]

Note on the Glacial Period.—[The geological teacher who takes his pupils on the field has a difficult task. Every valley almost that he can find is a case of pluvial and fluvial action, the evidence of ice action being rare in many districts. Yet the teacher has to teach the existence of the Glacial period by what is really the evidence of a Pluvial period.]

[The author has published this paper as read, with some slight alterations. He thinks it alludes to some points which should be more carefully considered by geologists than they have hitherto been. Fig. 2, Plate XI., has been corrected as to heights from the drawing exhibited in 1868. Fig. 3, Plate XI., is altogether new, and is inserted as necessary to explain Fig. 2 and the position of the Dour river referred to, in 1868, p. 396. Fig. 4, Plate XI., refers to the Binomial Curves spoken of in 1868, but not drawn, see note, p. 486.]—A.T., Aug., 1872.

*** The following note should have appeared on page 395, after line 12 from bottom:—The shape and height of any hill is dependent upon its power of resistance. Where the base is clay, exposed to the weather, or water action, either of the sea or brooks, the power of resistance is comparatively small. The presence of a thin band of clay in a position in which it could slip, might and has undermined and caused the denudation of strata thousands of feet thick in the Wealden area.

EXPLANATION OF PLATE XI.

NOTE BY MM. DEGOUSÉE AND LAURENT, IN EXPLANATION OF FIG. 1, PLATE XI.

The soil of Venice is only one metre above the high-water mark of the Adriatic. Most of the ground has been recovered from the deposit of alluvium which we have explored at twenty different points.

The first and the last beds of this deposit, of which the thickness is not less than 172 metres by the well-boring of the Ca di Dio, present a great similarity throughout. Nevertheless, the first beds contain shells generally all of marine species, together with fragments of human industry.

The lower beds contain fluviatile shells, intermixed more and more with marine shells.

The sands predominate towards the inferior part, and are frequently mixed with fragments of lignite disseminated through their mass. In the middle and upper parts these lignites occur in thin bands, and in beds alternating with clays or sands. Mica, very abundant in the lower part, is less so at the commencement of the deposit.

One may say that the beds of this deposit are almost horizontal throughout the area which we have explored. Thus, the two great lines which intervene between the soundings are—1st, of Guidecca to S. Francesco della Vigna, about two kilometres; 2nd, of Malghera to S. Servolo, about ten kilometres; it was to this last that we referred in our remark that it did not present any very great slope.

One would almost think the Venetians dreaded the scarcity of water, in the event of blockade, when one notices that everywhere there is abundance of spring water near the surface.

At Sta. Maria Formosa one finds five water-bearing beds, of which the first is at a depth of 2·50 metres. At St. Leonardo the water is found jetting up, at a depth of twenty-four metres. If at other points these different principal sources are not indicated, it is because they were of no importance, or were passed by unobserved; but it is probable that almost all these existed higher or lower.

Two principal beds illustrate the richness of these water-bearing alluvial deposits. The first, at forty-four to fifty-five metres, is so charged with gas, that at some points the expansion of the carburetted hydrogen gas projects the earthy matter (from the bore-hole) to a height of twelve metres. If a light is presented at the orifice of the boring from which the gas escapes, an explosion follows, and the gas continues to burn. The second water-bearing bed lies at an even depth of sixty metres ; it is not so charged with gas as the first, and the water flows from it constantly and with great regularity; it is found everywhere, but occasionally the pressure of the water varies.

In 1850, these borings yielded 1,029 litres of water per minute.

Degousée et Laurent.

Plate XI., Fig. 2.—Section along a line of eight miles from Folkestone to Dover, passing by the Holywell Spring B′ B″, thence to the watershed W′ on the west of the Sugarloaf Hill (a marked feature of the escarpment of the South Downs), thence by Alkham to the village of River and to Dover. See V′ V″ V‴. Sugarloaf Hill projects a little beyond the line of the main escarpment of the Chalk, but not so much as Beechborough Hill near Cheriton, which has almost the appearance of a tumulus. There is a line of springs and brooks along the whole escarpment; but the level of the springs gradually falls as it approaches the sea, or one of the Wealden Rivers. The level of the escape water is reduced thus, from 180 feet at Cherry Gardens to 140 feet at Holywell, about half a mile, at Lydden Spout, three miles further immediately on the coast the water escapes not far from high-water mark. The Springs above River, five miles from Holywell, are at a level of 112 feet above the sea (Fig. 2). The supposed underground water level is shown in Fig. 2 by a line A′ A″ A‴. This varies very much from year to year. In wet seasons the water level rises rapidly. When it changes as much as 20 feet, the springs overflow in a large bourne at Drillincourt (Fig. 2), making a temporary river.

Plate XI., Fig. 3 represents the alternations of coombs and headlands along the valley and hill separating Folkestone and Dover, or along the escarpment of the Downs. This is only a diagram and it does not attempt to describe any local features. It is drawn to show the manner in which all headlands and coombs alternate in every valley or escarpment, and along all lines of coast section, more or less symmetrically. The Springs S′ S″ S‴ rise near the Watershed W′ W″ in several points, and then collect in one channel, flowing into the cross stream at the bottom of the Valley V′ V″ V‴, always joining it in a single stream at an acute angle. The upper terminations are often trifid. The different distances from the watersheds, the flexures in the impervious and pervious beds affect the quantity discharged from each side stream S′ S″, and introduce local changes in their relative positions and magnitudes affecting the sizes and distances of the headlands. In a map of Crete, by Capt. Spratt, the distances of the side streams from each other are surprisingly regular. Fig. 3 shows the form of denudation in binomial curves (page 6), which govern the general shape of all headlands and coombs, hills and valleys; the hard or soft beds or clays also affect the stability of all strata, and produce deviations from the true binomial curve of denudation which are not attempted to be represented. The line B′ B″ B‴ in Fig. 2 would represent the transverse section of the headlands and coombs in Fig. 3. The remains of watercourses of the Pluvial Period are less visible on chalk escarpments than on any others, but in chalk valleys they can be traced.

Plate XI., Fig. 4 is a drawing of one of the infinite numbers of binomial curves of different powers and lengths that may be described. The base is divided into equal portions or abscissæ, and the ordinates are to scale, their lengths corresponding to the co-efficients of $(a+b)^{10}$. This form of curve was applied by Quetelet to represent the variations of lengths and numbers to illustrate certain statistical results; but the writer believes he was the first to indicate that actual accumulations as well as removals and elevations of materials forming the earth's surface, actually assumed a form which could be represented by binomial curves. He has measured beaches, flexures, as well as surfaces of valleys and hills, denuded by water, and found them coincide nearly with binomial curves. The binomial might be called the geological or physiographical curve, or the curve of denudation, or deposit, so marked is it in nature. It is essentially the heap curve. Everything heaped up, whether water in waves, or solids, like hay when heaped up, follow this curve. One of the principal characteristics of all binomial curves is that the upper part is convex, and the lower concave. The curve of a stream commencing at a watershed begins at 0, following a convex course, and gradually becomes steeper towards the middle portion, then

G. R. De Wilde lith. W. West & Co. imp.

Graptolites from the Moffat Group.

gradually flattens, following however a concave line; and when it enters a river, which has become navigable, passes into a parabola. In Fig. 3 the convex part is marked Hill H H; and the concave part, Valley, V V; and the convex or concave form of the surface enables us to divide a hill from a valley broadly. A new definition of a hill might be land situated above a valley having a convex form or surface, and that of a valley might be land situated below a hill, and concave in form.

The different powers of $(a + b)$ require a different number of divisions of the base line of the curve as well as different co-efficients, thus giving great variety to this form of the curve, while still preserving the feature of convexity and concavity pointed out. Hard rocks, or alternations of hard and soft, produce considerable deviations. No curve could be general in nature without great flexibility and variety, and the author thinks that Hogarth, who first tried to represent natural forms by particular curves, would have chosen the binomial as the line of grace, had he been aware of its properties.

The curves Hogarth has drawn have little variety, and therefore do not represent nature. Hard rocks do not always put on rugged features or outlines, they are sometimes denuded into smooth curves. In passing over the most varied formations, hills of identical contour but of different materials may be seen. The harder rocks have greater stability, and therefore are altogether larger, and stand up higher. May Hill and Shooters Hill, for instance, differ in size, but not in contour. No one can tell in all cases the formation from the surface alone. You may be certain that you are not looking at clay, but rock may put on various forms.

III.—On some New Species of Graptolites from the South of Scotland.

By John Hopkinson, F.G.S., F.R.M.S.

(PLATE XII.)

In this communication I purpose describing a few new forms of Graptolites which I have obtained at various times from the Llandeilo rocks of the south of Scotland. Of one species, first collected at Moffat in 1866, a brief diagnosis has previously been given, and the names of two others, from the lead-mining district of Lanarkshire, have already been published. One of these also occurs near Moffat. The remaining species are all from one or other of these richly fossiliferous districts. Of their position in the geological series I need only say here that the black, more or less carbonaceous, shale in which they occur, appears, from the fossils it contains, to correspond to the higher portion of the Llandeilo flags of Wales; that it is almost immediately succeeded by a series of beds (the Gala group) containing fossils of Caradoc or Bala age; and that the unfossiliferous flagstone, or greywacké, in which it occurs, reposes on rocks which have yielded to the persevering search of Prof. Elliot and Messrs. Lapworth and Wilson a few fossils of Cambrian age.

The Lanarkshire graptolitic shale is considered by Prof. Geikie to form "an upper part of the Moffat group,"[1] but while decisive stratigraphical evidence is wanting, from the evidence afforded by the fossils it seems more probable that but one band of graptolitic shale runs through the Llandeilo rocks of the south of Scotland, there being in this band several distinct zones, each marked by a different assemblage of fossils, but with many species in common.

Several of these new species were collected in the course of a few days' walking tour in these districts, during part of which I had the advantage of the company of Mr. Chas. Lapworth, of Galashiels,

[1] Brit. Assoc. Report for 1871, Sections, p. 96.

who has recently added greatly to our knowledge of the succession of the Cambrian and Silurian rocks of these southern uplands of Scotland, and who, I believe, will soon add several additional species to those here described. The first two species described do not belong to the Graptolitidæ proper, but are here included as nearly allied forms.

Class, Hydrozoa.

Order, Hydroida. Sub-order, Athecata ? Family, Corynoidea.

1. *Corynoides gracilis*, sp. nov.—Pl. XII., Fig. 1.

Polypary from about five-eighths to three-quarters of an inch in length, and about 1-50th of an inch in average breadth, gradually expanding from the proximal to the distal end, where there is a slight bulbous expansion terminating in short acutely-pointed teeth. Commencing with two slender radicular processes which lie so close together that they are scarcely individually perceptible, the polypary, here not 1-100th of an inch in breadth, gradually enlarges until a breadth of nearly 1–30th of an inch is attained. Up to this point the margins of the polypary are almost perfectly straight, but here there is a slight enlargement, which, in *C. calicularis* (Nich.), has been described as a "cup-like hydrotheca." This portion of the polypary is about 1-20th of an inch in length, and scarcely 1-20th in breadth at its widest part. It is convex in form, and terminates distally in about five acutely-pointed teeth, which at first sight appear to form the greater part of this so-called hydrotheca. But this appearance is caused by several fibres, somewhat resembling the virgula of the typical graptolites, which traverse the polypary throughout its length, and form the extreme distal termination of each of these segments, which are really connected together to within a very short distance of their apices. These fibres, whatever their nature may be, apparently form a framework which supports the less rigid and more membranous portion of the polypary, as the frame of an umbrella supports its cover.

This species differs from *C. calicularis*, the only one hitherto described, in its greater length and tenuity, and in the form of its expanded portion.

The systematic position of the genus *Corynoides* is very doubtful. Prof. Nicholson, its original describer, considers it to be "closely analogous to the *Corynidæ* or *Tubularidæ* of our own seas, especially resembling such forms as *Corymorpha*, in which there is but a single polypite. It cannot, however," he adds, "be considered to be absolutely referable to the *Corynidæ*, since no known Corynid exists as an independent or free-floating organism, such as *Corynoides* seems undoubtedly to have been."[1]

Whatever its mode of existence may have been, *Corynoides* could not belong to the Corynidæ, or Athecata, if it possessed a true hydrotheca. In some of the Athecata, however, the polypites are partially, and in one species at least, wholly retractile into the distal extremity of the polypary. I refer to such forms as *Atractylis arenosa*, and several species of *Perigonimus*. The polypite of *Corynoides* has very probably been similarly retractile, and as its non-contractile polypary would seem to preclude the idea of its having floated freely in the old Silurian seas, I consider that in the present state of our knowledge we cannot do other than place it provisionally amongst the Athecate Hydroida. At the same time I must admit that the absence of any hydrorhiza apparently capable of attachment to foreign bodies, in the true graptolites, as well as in the Corynoidea, renders it improbable that they resembled, in their mode of existence, the fixed Hydroida of our present seas.

Loc. *Llandeilo*:—Lochan Burn, Queensberry Hill, Dumfriesshire.

[1] Geol. Mag., Vol. IV., p. 108.

Order, Hydroida. Sub-order, Theoaphora? Family, Dendroidea.

1. *Dendrograptus ramulus*, sp. nov.—Pl. XII., Fig. 2.

Polypary with slender flexuous branches bifurcating at a wide angle and bending outwards after each bifurcation. Hydrothecæ about 30 to the inch, nearly twice as long as broad, rhomboidal in form, entirely free from each other, and with projecting sub-mucronate apices.

The branches usually occur in small fragments having a jointed or articulate appearance, due to the complete separation of their hydrothecæ from each other. They are about 1-50th of an inch in breadth. The hydrothecæ usually have a slight inclination outwards, or away from the dorsal margin of the branches, their proximal angle projecting slightly on this side, and their extreme distal angle or apex forming a rather more prominent projection on the frontal or outer side; but, owing to the varying direction of compression of the branches, they sometimes assume very different forms.

This species is very distinct from all the others of its genus. The wide angle of divergence of its branches, and their decided articulate appearance, are its chief characteristics. In form its thecæ somewhat resemble those of *D. gracilis* (Hall), but they are less triangular in shape, being very nearly, if not quite, as broad at their proximal as at their distal end.

More entire specimens of *D. ramulus* than have hitherto been found would be of value.

Loc. *Llandeilo*:—Wanlock Water, Wanlockhead, Lanarkshire.

Order, Hydroida. Sub-order, Rhabdophora. Family, Monoprionidæ.

1. *Graptolithus attenuatus*, Hopk. (Expl. Sh. 15, Geol. Surv. Scotl.)—Pl. XII., Fig. 3.

Polypary exceedingly slender, slightly curved, and with isolated, linear, or linear-tubular hydrothecæ, from 10 to 12 to the inch, rising from its convex margin at a very slight angle.

This little, fragile, monoprionidian graptolite seems to have been about an inch or two in length, none of the specimens examined exceeding an inch and a half, and this length is but rarely attained. The curvature of the polypary, though very slight, is constant in different individuals. The periderm is about 1–400th of an inch in breadth, and is thus of greater tenuity than in any other species of the genus. The proximal end of the hydrothecæ is not clearly defined, for they merge imperceptibly into the periderm at their origin. There appears, however, to be a slight interval between the distal end of each theca and the proximal end of the next. From their origin the hydrothecæ gradually widen to a maximum breadth of 1–150th of an inch, terminating in a rounded apex, which shows, when a front view of the polypary is obtained, a distinct circular aperture; but when the polypary is compressed so as to show a side view, these apertures are not visible, the apex of the thecæ being slightly pointed and free from the adjoining portion of the polypary.

This species seems to be more nearly allied to *Rastrites capillaris* (Carr.) than to any species of *Graptolithus*. It differs, however, from the typical species of *Rastrites* in its hydrothecæ being closely appressed to the periderm from their proximal to their distal end. It apparently forms, with *R. capillaris*, an intermediate link between the two genera, if they are really distinct.

The most nearly allied form in *Graptolithus* is Prof. Nicholson's var. *minor* of *G. Nilssoni* (Barr.), but in this variety there are nearly twice the number of hydrothecæ in an inch, and their form is very different. *G. tenuis* (Portl.), if it be not merely a variety of *G. Nilssoni*, is still further removed, its thecæ slightly overlapping one another, and the entire polypary being not nearly so slender as in *G. attenuatus.*

Barrande figures,[1] as a fragment of his *G. proteus*, a specimen which is most probably referable to this species; but as no description or enlarged figure is given, I cannot be certain of their identity.

Loc. *Llandeilo*:—Frenchland Burn, Moffat, Dumfriesshire; Kirk Gill, Leadhills, Lanarkshire.

2. *Graptolithus acutus*, sp. nov.—Pl. XII., Fig. 4.

Polpary slender, slightly curved, and with isolated, acutely angular hydrothecæ, about 25 to the inch, rising from its convex margin at an angle of about 30 degrees.

The periderm of this little graptolite is almost as slender as that of *G. attenuatus*, not exceeding 1–300th of an inch in breadth, but the form of the hydrothecæ is very different. The polypary is of unknown length, the only specimens I have seen being on a single piece of shale about an inch and a half square. The surface of the shale, however, is covered with them, there being portions of twenty or thirty individuals crossing it at all angles. The curvature of the different specimens varies very much, some being very nearly straight. The hydrothecæ are barely isolated from each other, the distal end of each theca reaching to, but never overlapping, the proximal end of the next. Their outer margin, which is slightly concave, forms an angle, with the axis, of about 20 degrees, and their distal margin, constituting the aperture, forms an angle of about 50 degrees with the axis, their apex being acutely angular or sub-mucronate. The maximum breadth of the polypary, or the distance between the apex of each theca and the dorsal margin of the periderm, varies from about 1-80th to 1-50th of an inch.

This species differs from *G. intermedius* (Carr.), the only form to which it bears any resemblance, in the greater tenuity of the polypary, and in the form of the hydrothecæ, which are longer than those of *G. intermedius* in proportion to their breadth. In the latter species, also, the thecæ rise from the periderm at a greater angle than in *G. acutus.*

Loc. *Llandeilo*:—Garple Linn, Moffat, Dumfriesshire.

Family, DIPRIONIDÆ.

1. *Diplograptus Etheridgii*, Hopk. (Expl. Sh. 15, Geol. Surv. Scotl.)—Pl. XII., Fig. 5.

Polypary about an inch in length and 1-30th of an inch in breadth at its widest part, slightly contracted towards the proximal end, and gradually decreasing in breadth towards the distal end; with a radicle and lateral spines and a distally prolonged virgula. Hydrothecæ from 30 to 35 to the inch, forming but a slight angle with the axis, slightly overlapping one another, and with a curved outline and rounded apex. Apertures appearing as minute circular depressions at the distal end of each hydrotheca.

At the proximal end of the polypary two spines only are usually seen, the central radicle being seldom perceptible. The polypary almost immediately attains its maximum width, and then contracts, for some distance almost imperceptibly, and then gradually more rapidly, towards its distal end, the virgula, or so-called "solid axis," being almost invariably prolonged beyond the other portions of the

[1] Grapt. de Bohême. pl. iv., f. 3.

polypary for about half an inch, and sometimes for a greater distance. The hydrothecæ have usually the appearance of rounded knobs, their outer margins forming a continuous curve, at first concave, and then, for about half their length and round their apertures, convex.

This species somewhat resembles *D. angustifolius* (Hall), but is very much narrower, and has hydrothecæ more nearly approaching in form those of *D. Hughesi* (Nich). As a rule, it is readily distinguishable, amongst the species with which it is associated, by not having the same glistening appearance. It would seem to have had a thinner or more fragile polypary than is usual in its genus.

I name the species after Robert Etheridge, Esq., F.R.S., Palæontologist to the Geological Survey of Great Britain, to whom I am indebted for the opportunity of examining, at the Geological Museum, a collection of graptolites amongst which I first recognized this form.

Loc. *Llandeilo* :—Wanlock Water, Wanlockhead, Lanarkshire.

2. *Diplograptus penna*, Hopk., Journ. Quekett Micros. Club, vol. i., p. 159, pl. viii., fig. 12.—Pl. XII., Fig. 6.

Polypary about 1-10th of an inch broad, of unknown length, and with the periderm and virgula distally prolonged. Hydrothecæ 20 to the inch, never overlapping one another, their outer margin convex, forming an angle of about 45 degrees with the axis, and entirely free, and their distal margin, or margin of the aperture, concave, and at right angles to the axis.

From the proximal to the distal end the polypary gradually widens, attaining its full width of 1-10th of an inch at the last developed hydrothecæ. The entire polypary attains a length of at least two inches; but of the few specimens I have seen not one has had both its extremities entire. The distal prolongation of a portion of the polypary destitute of hydrothecæ has only been seen in the specimen figured. That this prolonged portion is the common tube or periderm seems to be shown by the presence, throughout its entire length, of a slender fibre, which, from its central position and distinct appearance, I have inferred to be the virgula. This periderm appears, between one or two of the last-formed or most distal hydrothecæ, as a distinct structure—its junction with the thecæ on either side being well defined. It is here about 1-40th of an inch in width, and shows transverse striæ; but as it leaves the thecæ these markings disappear, and it contracts to nearly half this width. It then gradually expands, attaining, at about two-thirds of its length,[1] a width of fully one-tenth of an inch, and gradually contracting to an obtusely acuminate point. This free portion is about an inch and a half in length. Whether the hydrothecæ have never been developed along it, or after having budded from it have disappeared, or have been destroyed during fossilization, we have no certain data to determine. From its varying width—its extensive dilatation and acuminate apex more especially—the former supposition seems to be the most probable.

This curious structure is possibly morphologically identical with the "axial tube" which, in *D. vesiculosus* (Nich.), is stated to take the place of the "ordinary solid axis." In this species, however, Prof. Nicholson says that the presence or otherwise

[1] Near this point an accidental fracture is seen. It is represented in the figures.

of a true solid axis in addition to the axial tube cannot be determined. May not the axial tube with its terminal vesicle be merely a modification of the ordinary common tube or periderm? Such a modification seems more probable than the superaddition of a distinct organ unknown in any other graptolite, or in any recent hydroid zoophyte.

The hydrothecæ of *D. penna* differ widely from those of *D. vesiculosus*,[1] being entirely free from each other to their junction with the periderm. They thus, also, differ in this point, as well as in their general form, from those of *D. pristis* (His.), to which species *D. penna* seems to be nearly allied.

Loc. *Llandeilo*:—Frenchland Burn, Moffat (and near Moniare ?), Dumfriesshire.

3. *Diplograptus pinguis*, sp. nov.—Pl. XII., Fig. 7.

Polypary ovate in form, about half an inch in length, and fully a quarter of an inch in breadth, exclusive of its lateral spines and of the prolongations of the virgula, which terminates proximally in a well-marked radicle and is prolonged distally. Hydrothecæ about 10 to the inch, with a slender spine at their apex, and with a concave aperture extending partly across the polypary at right angles to the axis.

Commencing with a very slender radicular process, flanked by two equally slender spines, indicating the apices of the first-formed thecæ, the polypary rapidly widens, attaining its full width at about a fifth of an inch from its origin, and then gradually becomes narrower to its distal end, from which the virgula is prolonged as a slender process for at least half an inch. The hydrothecæ, owing to the imperfect state of preservation in which this species is found, are scarcely perceptible, being usually indicated only by their spines, which are slender, vary in length from 1-20th to nearly 1-10th of an inch, and form a continuous line with the margin of the aperture.

I have seen very few specimens of this species, and have only one sufficiently distinct to show the above characters, and this, being a mere pyritous stain on the surface of the shale, has lost the distinct brilliant appearance it had when first exposed, as a fossil, to the light.

D. armatus (Nich.) is the only species to which *D. pinguis* bears any resemblance, but this species is very much narrower and has much longer spines, which are described as "broad, tapering, and slightly deflexed," and are thus totally distinct from the minute, slender, spinous processes of *D. pinguis*.

Loc. *Llandeilo*:—Sowen Dod, Wanlockhead, Lanarkshire.

4. *Diplograptus fimbriatus*, sp. nov.—Pl. XII., Fig. 8.

Polypary about half an inch in length and 1-16th of an inch in breadth throughout, with a minute radicle and lateral spines and a distally prolonged virgula. Hydrothecæ about 40 to the inch, overlapping one another for fully half their length, inclined to the axis at an angle of from 10 to 20 degrees, and with mucronate apices and slender spines. Apertures appearing as minute circular or slightly elongated scalariform impressions.

At the proximal end the polypary is obtusely rounded and fringed with slender spines, the central one representing the radicle. The margins of the polypary are parallel throughout, and are also fringed with these spines, which do not appear to proceed, as usual, from the apertures of the hydrothecæ, but from a point which pro-

[1] This species, whether with or without its terminal vesicle, may be easily distinguished from *D. pristis*, to which it has been erroneously referred. In the Moffat shales it characterizes a distinct zone, and is not associated with *D. pristis*.

jects slightly beyond the general margin of the polypary, and apparently forms the extreme distal termination of each hydrotheca. Their apertures do not reach to this point, and in the usual direction in which the graptolite is compressed, appear in the centre or between the centre and the margin of the polypary, as circular or oval depressions. The spines are about 1–20th of an inch in length, and are usually slightly curved. The form of the hydrothecæ cannot be accurately determined, owing to the direction in which the species is compressed. Distally the polypary ends abruptly, never contracting, as it almost invariably does in other species, and the virgula is prolonged for about half an inch or more.

This species differs from all others of its genus in the number of spines with which the proximal end is furnished; and in the parallelism of the margins of the polypary from all but *D. vesiculosus*, to which species it has not the slightest resemblance in other respects.

Loc. *Llandeilo*:—Wanlock Water, Wanlockhead, Lanarkshire.

5. *Diplograptus Hincksii*, sp. nov.—Pl. XII., Fig. 9.

Polypary two or three inches or more in length, and an eighth of an inch in breadth at its widest part; the proximal end furnished with a slender radicle and lateral spines, and the margins with very conspicuous spines about an eighth of an inch apart. Hydrothecæ about 24 or 25 to the inch, decreasing but slightly in width from their junction with the periderm to their apertures, which usually appear as transverse oval impressions on the surface of the polypary.

Near the proximal end, the polypary, exclusive of its lateral spines, is about 1-16th of an inch in breadth, gradually increasing to fully 1-8th where the most distal hydrothecæ are seen. The first, or radicular spines are bent slightly towards the radicle, the remaining lateral spines being directed outwards. These spines, which average 1-8th of an inch in length, are at first in the proportion of about ten to the inch, but the distance between them gradually increases, until, near the distal end of the polypary, there are only eight in the space of an inch. They originate from the polypary in a lateral direction, having apparently budded from the periderm at right angles to the hydrothecæ, to which they bear no even numerical proportion. In these respects they are similar to the reproductive capsules which have been observed on *Diplograptus pristis* (His.); but they show no decisive evidence of real analogy with them. That they have had some connexion with the reproductive process, seems, however, not improbable. The exact form of the hydrothecæ, owing to their being shown as "scalariform" impressions, cannot be determined, but they have evidently had a larger aperture than is usual in this genus. Its transversely long and narrow form appears to be partly due to compression, the entire hydrothecæ having most probably been originally similar in form to those of *D. putillus* (Hall).

For the illustration of this species I have chosen three specimens which occur on the same piece of shale, and in the position in which they are figured. Of these, one only appears to be entire and full grown, another is certainly a young form, and the third is only a fragment, but each one illustrates some peculiarity in this curious species. In the smallest specimen, of which the distal end only is seen, beyond the last developed hydrothecæ there is an extension of what appears to be the periderm, and again, beyond this, the virgula is prolonged for a considerable distance. In the more entire, but younger form, the periderm is seen to be prolonged for about half an inch, and no virgula is apparent. In the mature and perfect form, beyond the most distal hydrothecæ, the periderm seems to have split in two; one portion, of which only about a third of an inch is seen, is slightly bent outwards, while the other portion is continued in a nearly straight line for about an inch and a half.

A full consideration of the various questions which these forms suggest must be reserved for another occasion.

I name this species after the Rev. Thomas Hincks, F.R.S., author of "A History of the British Hydroid Zoophytes," to whom I am indebted for valuable information on these recent representatives of the Graptolites.

Loc. *Llandeilo* :—Sowen Dod, and Wanlock Water, Wanlockhead, Lanarkshire.

Family, Monodiprionidæ.

1. *Dicranograptus rectus*, sp. nov.—Pl. XII., Fig. 10.

Polypary with a very short diprionidian stem, wider near the axil than at the proximal end, and dividing acutely into two long and almost perfectly straight monoprionidian branches, which diverge from each other at an angle of about 20 or 30 degrees. Hydrothecæ from 25 to 30 to the inch, free for about half the width of the polypary; curvilinear in outline, and slightly incurved towards the distal end. Apertures forming an angle of about 45 degrees with the axis.

The stem is provided, as in all the species of the genus, with a radicle and two lateral spines, processes from the first formed thecæ. It varies in length from 1-10th to 1-5th of an inch, its length not increasing with the age of the individual, for specimens with branches not more than an inch long seem to be more frequently provided with stems of the full length than those in which the branches have attained the length of three or more inches. The outer margins of the branches are continued in a straight line to the proximal end of the stem, the margins of which thus form the same angle with each other as the branches. At the axil a breadth of 1-10th of an inch is sometimes attained. The branches vary from 1-30th to 1-20th of an inch in breadth, and are usually perfectly straight, but sometimes curve slightly inwards towards their distal end. The hydrothecæ have the curvilinear form peculiar to this and the allied genus *Dicellograptus*, with the usual pouch-like indentations within which the apertures are situated. Their outer margin is slightly indented, and in the stem, and for a short distance along the branches, within this indentation there is a slight protuberance from which proceeds a slender spine, directed outwards, or but slightly towards the distal end of the polypary. In general form the hydrothecæ seem to be intermediate between those of *D. Nicholsoni* and *D. formosus* (Hopk.).

This species differs from all the others of its genus in having an exceedingly short stem in proportion to the length of its branches, and in its branches being but very slightly, if at all, curved.

From the numerous specimens of this and other species of *Dicranograptus* which I have seen in the neighbourhood of Wanlockhead, I am convinced that, within certain limits, the length of the stem furnishes a character of specific importance. *D. ramosus* (Hall) may be thus distinguished when the branches are only just beginning to bud, and *D. Nicholsoni* (Hopk.) may be determined by the characters shown by its stem when but a single hydrotheca has been developed on each rudimentary branch.

Loc. *Llandeilo* :—Laggen Gill, Leadhills, Lanarkshire.

EXPLANATION OF PLATE XII.

FIG. 1. *Corynoides gracilis.* 1*a*. A specimen natural size. 1*b*. The distal end magnified 5 diameters. 1*c*. The proximal end mag. 5 dia.
FIG. 2. *Dendrograptus ramulus.* 2*a*. A specimen nat. size. 2*b*. Part of a branch mag. 5 dia. 2*c*. Another specimen nat. size.
FIG. 3. *Graptolithus attenuatus.* 3*a*. A specimen nat. size. 3*b*. A portion mag. 5 dia. 3*c*. Three hydrothecæ mag. 10 dia.
FIG. 4. *Graptolithus acutus.* 4*a*. A group nat. size. 4*b*. Part of a specimen mag. 5 dia.
FIG. 5. *Diplograptus Etheridgii.* 5*a*. A specimen nat. size. 5*b*. and 5*c*. The distal and proximal ends mag. 5 dia. 5*d*. Another specimen nat. size. 5*e*. Part of a specimen collected by the Geol. Surv. of Scotland, enlarged.
FIG. 6. *Diplograptus penna.* 6*a*. A specimen nat. size. 6*b*. and 6*c*. Portions mag. 5 dia.
FIG. 7. *Diplograptus pinguis.* 7*a*. A specimen nat. size.
FIG. 8. *Diplograptus fimbriatus.* 8*a*. A specimen nat. size. 8*b*. and 8*c*. The distal and proximal ends mag. 5 dia. 8*d*. Another specimen nat. size.
FIG. 9. *Diplograptus Hincksii.* 9*a*. A specimen nat. size. 9*b*. A portion mag. 5 dia. 9*c*. An imperfect specimen nat. size. 9*d*. A young specimen nat. size.
FIG. 10. *Dicranograptus rectus.* 10*a*. A specimen nat. size. 10*b*. Part of a branch mag. 5 dia. 10*c*. The proximal end mag. 5 dia.

IV.—ON THE RELATIONS OF THE MIDDLE AND UPPER SILURIAN (CLINTON, NIAGARA, AND HELDERBERG) ROCKS OF THE UNITED STATES.

By Professor JAMES HALL, of Albany, U.S.A.
Foreign Member of the Geological Society of London.

IN the general classification of the Palæozoic Rocks of North America, while we have carefully compared and attempted to correlate them with the greater divisions of the Silurian, Devonian, and Carboniferous systems of Great Britain and the continent of Europe, we have still retained the local names of formations, which to a great extent were given in the Geological Survey of New York. These names, like English local names, indicate a locality or region where the strata are well shown, and the characteristic features of the formation better developed than in other places. Several of these local formations have thus been grouped together as representing certain stages in the systems of formations as recognized above.

In this grouping together we have the Medina Sandstone, the Clinton Group, and the Niagara Group as representatives of the Middle Silurian, while we arrange the Water-lime and Lower Helderberg Groups in the Upper Silurian strictly. These two divisions are clearly separated from each other by the *Onondaga Salt Group* as shown in the subjoined diagram (1) thus:

Upper Silurian	Lower Helderberg Water-lime.	
	Onondaga Salt Group or Salina formation.	
Middle Silurian	Niagara Group.	
	Clinton Group.	
	Medina Sandstone.	
Lower Silurian	Hudson River Group.	
	Trenton	Limestones.
	Black River	
	Birdseye	

Below these come the well-marked Lower Silurians, the equivalents of the Caradoc and Llandeilo formations.

The geographical distribution of the Middle and Upper Silurian in the United States and Canada is very clearly determined and extremely different in the two divisions. Each one of these divisions has been the subject of long-continued study and careful investigation. Each one of them has furnished materials for a volume of the Palæontology of the State of New York, and it may be said with confidence that there is scarcely a single species common to the two formations. Representative species do occur in the two divisions; and wherever the physical conditions have been similar during the two epochs, the species occurring in those beds bear a close similarity to each other. But the entire assemblage of fossils is so different that from these alone (leaving out of consideration the relative position of the formations), no good Palæontologist would recognize them as the fauna of a single era in geological time.

In a paper read before the American Association for the Advancement of Science in 1870, Mr. A. H. Worthen, the State Geologist of Illinois, proposes to dispense with the subdivisions Niagara and Lower Helderberg Groups, and gives his reasons for regarding them as one and the same, and that the nomenclature of the science is thus unnecessarily burdened with two designations for the same formation. He bases his conclusions upon observations made in the Schoharie valley, where, he asserts, the Lower Helderberg Group rests directly upon the Sandstones of Lower Silurian age, the Hudson River Group.

Having, during the last thirty years, been familiar with the Schoharie valley and its tributary valleys, and having made sections of the strata at more than twenty different points, I am compelled to say that I have nowhere witnessed the phenomenon asserted by Mr. Worthen. Everywhere, and unmistakably too, the lowest member of the Lower Helderberg Group is separated from the sandstone of Lower Silurian age by *two* or *three* distinct and well-marked members of the series. In order to show the true relation of the rocks of the Schoharie valley, I present the following section, which may be verified in numerous localities in the Schoharie and Kobel's Kill valleys.

	Oriskany Sandstone.
Lower Helderberg Group	Upper Pentamerus Limestone.
	Shaly Limestone.
	Lower Pentamerus Limestone.
	Tentaculite Limestone.
	Water-lime Formation.
	Coralline Limestone.
	Green Shales with Iron Pyrites.
LOWER SILURIAN	Sandstones of the Hudson River Group.

Here it will be distinctly observed that the lower member of the Lower Helderberg Group is separated from the sandstones of the Lower Silurian system by an impure Magnesian Limestone, which, though usually destitute of fossils, contains in some localities great abundance of that remarkable Crustacean the *Eurypterus*, and more rarely its allied form *Pterygotus*. The Coralline Limestone, as its name indicates, contains numerous corals, among which are *Halysites* *catenulatus*, *Favosites Niagarensis*, etc., and Brachiopoda of several genera. Two or three species of Trilobites also occur in the same rock.

The green shale with iron pyrites has a thickness of thirty or forty feet, and, so far as known, is destitute of fossils. The proportion and amount of iron pyrites is very great, and near the base of this bed there is often a distinct layer of iron pyrites, which has, to some extent, been mined for economic uses. This feature is of interest mainly in connexion with some suggestions I propose to make regarding the characteristics of this part of the formation in its western extension.

Without occupying the time of the Association with details of observations and sections at numerous points, I propose to present a corresponding section at a point about sixty or seventy miles west of the Schoharie valley, where the preceding section may be verified.

We have still the same general features of country, and the greater geological divisions are well marked.

Lower Helderberg Group	Oriskany Sandstone.
	Shaly and Lower Pentamerus Limestone.
	Tentaculite Limestone.
	Water-lime Formation.
	Red and Grey Marls of the Onondaga Salt Group.
Niagara Group	Coralline Limestone.
Clinton Group	Green Shales and Beds of Red Hæmatite.
Medina Sandstone	Red and Grey Sandstone.

At a point one hundred miles further west we have the following section:

	Oriskany Sandstone.
Upper Silurian	Water-lime Group.
	Onondaga Salt Group.
Middle Silurian	Niagara Group.
	Clinton Group.
	Medina Sandstone.
Lower Silurian	Hudson River Group.

At this point every vestige of the Lower Helderberg Group has disappeared, and the Water-lime and Onondaga Salt Group have become developed to a thickness of more than one thousand feet. The Niagara Group in its divisions of Shale and Limestone, and with its characteristic fossils, is a well-marked feature. The Clinton Group, with its abundant iron ores, has reached its maximum thickness to the east of this point, and in the neighbourhood of the second section.

Still following these formations to the westward, we obtain everywhere for several hundred miles essentially the same order of succession, with the absence of the Oriskany Sandstone. This is shown upon the geological map, and the formation may be traced through Western New York, Ohio, Canada, the Islands of Lake Huron, Wisconsin, Illinois, Iowa, and Missouri. Nowhere in this direction till we reach the Mississippi in the southern part of Missouri and Illinois, do we find the least evidence of the limestones or of the fossils of the Lower Helderberg Group.

Now, returning again to our point of departure in the Schoharie valley, we can trace the Lower Helderberg group of beds to the east and south everywhere underlaid by the Water-lime formation. The blue line marked upon the map indicates the geographical extension of the formation, which is everywhere marked by its characteristic fossils, and everywhere resting on the Water-lime beds, through all its meanderings caused by the plications of the strata through south-eastern New York, Pennsylvania, and Maryland.

The Coralline Limestone can be traced southward for fifty miles along the Hudson River valley, but is lost to observation near the southern limits of the State, and I do not know that the same or equivalent formation has been recognized in Pennsylvania or Maryland. In some parts of Maryland at least the Water-lime rests on shales of the Clinton Group.

Returning again to the point of first starting, we are not able to take up a continuous line of outcrop ; but the Lower Helderberg group has been determined by Sir William Logan in the neighbourhood of Montreal. It is largely developed at Gaspe and other places in Canada, and apparently constitutes the main feature in the Limestone formation of this age, so clearly drawn out on the great map of Sir W. E. Logan.

Not being personally familiar with this area of country, I am of course unable to enter into the details regarding the individual members of the series ; but I believe that throughout this great extent the Niagara group, as known in New York and Canada West, has scarcely any existence.

Whatever Upper Silurian fossils there may be which are not strictly referable to the Lower Helderberg Group are from beds distinctly separable from it, and lying at a lower horizon. I say this of my own personal knowledge, having critically examined the collections of the Geological Survey of Canada made near Montreal, and at Gaspe and elsewhere.

So far, therefore, we find both the physical fact of super-position and the evidence of fossils coinciding to prove the Lower Helderberg group a distinct and overlying formation to the Niagara group, and separated from it by the Onondaga Salt group and Water-lime formation, wherever these latter formations exist.

It is claimed, however, that in southern Illinois, Missouri, and in Tennessee the Niagara and Lower Helderberg groups are physically and zoologically inseparable. Having seen these formations in Missouri, I am prepared to assert and to prove that the Lower Helderberg and Niagara formations are both physically and by their fossil contents distinguishable the one from the other.

With the localities in Tennessee I am not so familiar ; but from the examination of large collection of fossils collected in that region, and from the sections given by Prof. Safford, I believe the formations to be quite distinct. It happens, however, from the thinning out of the Salt Group, and Water-lime formations, that the disputed groups of strata do come in contact ; and the facts which would prove a lapse of time between the ending of the one and the beginning of the other have not yet been observed, or if observed, have not received that consideration to which they are entitled.

While therefore the actual physical and zoological distinction can be traced in a westerly direction for more than twelve hundred miles, and in a north-easterly direction for six or eight hundred miles, and for an equal distance in a southerly and south-westerly direction, I can scarcely suppose that the few facts observed within limited areas, and not yet submitted to the test of comparison, will change the views of geologists upon the distinctive character of these formations.

In bringing this brief *résumé* before the Geological Section of the British Association, I have indulged in the hope that the facts might be of some use in a comparison with British Middle and Upper Silurian formations, which can be so clearly recognized in Canada and the United States.

V.—Note on the Midford Sands.

By H. B. Woodward, F.G.S.,
Of the Geological Survey of England and Wales.

The term "Midford Sands" suggested by Professor Phillips[1] for the Sands which occur between the Inferior Oolite and the Upper Lias Clay, gives us a very happy name, and one that has been long wanted for these beds; for hitherto although they have been called by many names, not one has been generally adopted. They were first discovered and studied, so Professor Phillips tells us, by William Smith, in the picturesque cliff which overhung his house at Tucking Mill, near Midford—a little hamlet about three miles south of Bath, and situated in one of those delightful valleys formed by the river Avon and its tributaries. The deposit was called by him "Sand of the Inferior Oolite," and so it was known until Dr. Wright in 1856[2] called the classification into question on palæontological grounds, and maintained that the fossil evidence indicated that the Sands belonged rather to the Lias than to the Inferior Oolite. He gave them the name of "Upper Lias Sands," by which they have since been usually designated. The classification of Dr. Wright has, however, been objected to, and it may therefore be interesting briefly to review some of the opinions in regard to this question, stating also that most recently given by Professor Phillips.

Dr. Wright pointed out that wherever the Sands are well exposed (and he gave sections in Gloucestershire and Dorsetshire), they are overlain by a brown iron-shot marly limestone containing "an immense quantity of individuals of several species of Ammonites, Nautili and Belemnites, with a few shells of other Mollusca," and he maintained that this "Cephalopoda Bed" in its organic remains belonged rather to the Lias than to the Oolite formation. The Sands below he found to pass insensibly into the clays of the Upper Lias.

Mr. Moore,[3] however, has disputed these conclusions. He remarks

[1] Geology of Oxford and the Valley of the Thames, p. 109.

[2] Quart. Journ. Geol. Soc., vol. xii., p. 292.

[3] On the Middle and Upper Lias of the South-west of England. Proc. Somerset Arch. and Nat. Hist. Soc., vol. xiii., 1865-6.

that the faunas of the Upper Lias and Sands are very distinct in general facies, and that many Ammonites pass from the Sands into the Inferior Oolite above. The Sands, moreover, he states, are often inseparable from the Inferior Oolite into which they pass gradually upwards; while he mentions that at Compton, near Sherborne, the upper surface of the Upper Lias, composed of thin bands of clay and stone, "was much eroded before the deposition of the Oolitic bed above, a circumstance observable wherever the junction of the Upper Lias with the Sands is exposed."

This last statement, however, is at variance with that of other observers, who regard the beds as passing one into the other; and as the fossil evidence tends to confirm the opinion, we are inclined to regard the appearance of erosion as a local peculiarity. Unfortunately the junction of the Sands with the Lias is very rarely seen in section, although usually it is clearly marked by springs which are thrown out by the Upper Lias Clay.

Judging solely from Dr. Wright's list of fossils we find that taking into consideration the Cephalopoda alone, the Sands are more nearly related to the Upper Lias; while arguing from the Gasteropoda, Conchifera, and Brachiopoda, they are more closely allied to the Inferior Oolite.

Therefore the palæontological evidence cannot be looked upon as decisive for referring the Sands more particularly either to the Upper Lias or the Inferior Oolite, but that it agrees with the evidence afforded by the rocks of a gradual change.

This is indeed the opinion arrived at by Mr. Lycett[1] in the Cotteswold Hills. Here he has called the Sands the "Cynocephala stage," from their being characterized by *Rhynchonella cynocephala*, which occurs in the "Ammonite bed" (= "Cephalopoda bed" of Dr. Wright). He observes that it is a stage "possessing some features both petrographic and zoological, which seem to claim for it a position intermediate and connecting the Lias with the Inferior Oolite." He considers that the group of fossils found in the "Ammonite bed" differs very materially from the Upper Liassic fauna, and that even the evidence afforded by the Ammonites is "transitive" in its character. He also alludes to the division between the "Ammonite bed" and the Oolite above, as being often very indistinct.

Professor Phillips[2] has pointed out the transitional character of the Midford Sands as a very general fact in Yorkshire, Lincolnshire, Gloucestershire, and Dorsetshire; that they were "deposited on the Upper Lias clay in such a manner as often to defy the geologist to draw a hard line between them," and that "the Oolite above seems to connect itself with equal affinity to shelly calcareous rock [the Cephalopoda bed] at its base." And in regard to the organic remains, he remarks that, "before the Liassic life has come to an end, the Oolitic life has begun."

It is important, however, to notice the statement of Mr. Moore in

[1] The Cotteswold Hills. Hand-Book introductory to their Geology and Palæontology. pp. 16–33. (London, 1857. 8vo.)

[2] *Op. cit.*, p. 118.

regard to the indication of a slight lapse of time between the conclusion of the Upper Lias and the commencement of the Midford Sands in the Somerset and Dorset area, where we have such afeeble representative of the former. Indeed, but for Mr. Moore's patient investigations it would be but little known in this area, for his observations show that it attains but an average thickness of 8 feet in Somersetshire and the adjoining portions of Dorset. It has therefore been generally too thin to trace out on the small scale of the Geological Survey Map; but its presence was indicated and a small exposure mapped near Sandford Orcas more than twenty years ago by Mr. Bristow.

Although, as Mr. Moore points out, these Upper Lias beds "present a remarkable variety in lithological condition, indicating that they must have been deposited slowly, and that there were probably periods of rest during their accumulation,"[1] yet it becomes an interesting question when we compare this feeble representative of the Upper Lias with the great thickness it reaches in the north of England, to speculate as to whether Oolitic conditions may not have commenced somewhat earlier in this part than elsewhere.

Professor Buckman has recently given his opinion in regard to the Sands near Sherborne in Dorsetshire, that they belong to the Inferior Oolite series; that the concretionary masses interbedded with the sands contain fossils essentially Oolitic, and not Liassic. He considers them to be the equivalents of the Middle and of a portion of the Upper division of the Inferior Oolite of Gloucestershire, and the "Cephalopoda Bed" of this district he states to be at the top, instead of at the base of the Oolite.[2]

This opinion shows the difficulty of correlating these divisions of the Secondary rocks with any exactness. Indeed we are inclined to think it impossible, and to look upon the whole of the rocks, the Keuper, the Lias, and the Oolites, as one conformable series, marked for convenience into certain stages of sedimentary deposit, which are also characterized by certain assemblages of organic remains; but we do not think that these stages continued uniformly, or that they were of a like duration over any large area, the conditions changing at different times in different places. In this way we may understand some of the marked differences in thickness of the rocks, which do not seem always to be accounted for by rate of deposition, and certainly do not admit of denudation to account for their attenuation. We may mention the Fuller's Earth, which attains a thickness of 400 feet in Dorsetshire, which entirely disappears to the north-east beyond Gloucestershire, as an instance of a deposit contemporaneous with others of a different character.

The subject requires much study before we can look upon the Lower Mesozoic rocks as a series of interlacing sediments.[3]

[1] *Op. cit.*, p. 17.

[2] Proc. Geol. Assoc., vol. ii., p. 249.

[3] Mr. Bristow has prepared an interesting Table, showing the thicknesses of the Secondary strata in the Southern counties of England, which is published in the Report of the Coal Commission.

VI.—Account of an Expedition to Greenland in the year 1870.

By Prof. A. E. Nordenskiöld,

Foreign Correspondent Geol. Soc. Lond., etc., etc., etc.

Part V.

(*Continued from page* 463.)

NOTWITHSTANDING the very inconsiderable amount of sulphur it contains, this Greenland iron has a remarkable tendency to fall to pieces by the action of the air. The weathering depends on an oxidation, probably produced by a quantity of chlorine contained in the iron, and its great porosity; nevertheless, some of the phenomena connected with the weathering still appear to me inexplicable. I shall therefore somewhat more fully detail the observations and experiments made towards explaining this very disagreeable circumstance.

The Ovifak meteoric iron does not fall to pieces at the place where it was found, though sometimes washed by the sea, sometimes left bare; but on the shore it was preserved at the temperature of the sea, which varies but little during the whole year.

Even during the passage, when the masses lay packed in wooden chests in the hold, and were exposed to a very moist atmosphere and at a temperature but little above freezing-point, the unbroken stones did not suffer perceptibly; whereas almost all the fragments packed in the same manner split into pieces, more particularly those which I had preserved in the heated cabin.

From some of the pieces of iron sea-green drops oozed out, which afterwards became reddish brown by the action of the atmosphere. They contained protochloride of iron with traces of sulphate.

One of the larger pieces, which, after our return home, was placed in a room of ordinary temperature, soon began to crack on its surface, and ultimately, when unpacked two months later in Stockholm, crumbled to a reddish brown powder, consisting partly of a fine rust powder, partly of angular bits of iron, rusty on the surface, and varying in magnitude from the size of a pea to that of a hemp-seed. An entirely unchanged, and therefore, on a fresh surface of fracture still metallic, portion of Stone 4, began at one corner to rust, swell and crumble, while the remainder of the iron remained unaltered. The rust spread itself like a fungous growth over the rest of the piece, and extended itself to the interior, which thereupon swelled and crumbled like an efflorescent salt. During this time the weight of the piece of iron increased.

Weight of a fragment of iron when packed	29·935 gr.
,, ,, after 129 days	30·143 gr.
Weight of the unchanged iron	24·529 gr.

so that 5·406 gr. had weathered away to a rusty-brown powder and during this time had increased in weight 0·208 gr. or 3·8 per cent.

In a hermetically sealed glass tube the iron was completely unchanged.

In a glass tube, that had been hermetically sealed, but in which a fine crack had taken place in cooling, the iron continues to crumble

In a eudiometer over mercury, the iron in a few days absorbed a considerable amount of oxygen, in consequence of which the mercury rises in the tube.

In alcohol, the iron does not crumble. In water, it rusts, but does not appear to fall to pieces.

In air dried by sulphuric acid the crumbling process takes place slowly.

Varnishing does not fully protect these pieces of iron from weathering, not even if immersed in warm copal-varnish. I thought at first that the cracking was the result of the contracting and shrinking of the mass, but this is not the case. On the contrary, the cracking is caused by dilatation. With what force this operates may be judged from the fact, that a piece of iron, on which chisel and saw are without effect, is broken or bent by the decomposition of the mass. In general, cracks first appear at right angles to the surface of the stone; these diverge as from a centre, and at a depth of a few lines below the surface of the stone meet a crack that runs parallel with the surface, which, by the swelling of the overlying crust, is soon formed into a little dome, sometimes an inch in height. In the mean time the overlying crust is raised, doubled up and broken in a manner which bears a striking likeness to the doubling of the stratified rocks by the so-called eruptive forces,—that is, if one supposes that the cracks, instead of being empty, are filled with detritus, which gradually hardens to an "eruptive" rock.

When fragments of the largest stone weighing 134 gr. were heated to redness, they parted with nearly two litres of gas, or about 100 times the volume of the iron, as also a considerable amount of water, which, like the gas, had a bituminous smell. The gas was clearly no primary constituent, but formed partly by the decomposition of organic matter in the meteorite, partly by the reducing operation of compounds containing carbon on the oxide of iron in the meteorite, which was found to be completely reduced at the termination of the experiment. On the iron being dissolved in chloride of mercury, only a trifling quantity of gas was emitted, probably coming from the pores in the iron. In hydrochloric and nitric acid the meteoric iron is dissolved, leaving in some cases a residue containing much carbon, in others very little residue at all. The gas that escapes during solution in hydrochloric acid has a most penetrating smell, probably due to some hydrocarbon. On dissolving Ovifak iron, which has been heated to redness, in air or oxygen, in acid, there often remains a flocky, voluminous, brown material soluble in warm, but hardly so in cold water, which in ammonia is very easily dissolved, forming a dark brown, almost opaque fluid. The same material is obtained from the carbon that remains after the solution of the iron in acids. It can again be precipitated by means of acids from the ammoniacal solution, though not quite completely, so that the acid solution is also brown, but of a very light tint. This material is a humus-like compound, which probably did not originally exist in the meteorite, but arises from the solution of the carboniferous iron in acids.[1] This humus-like body can be broken

[1] A similar substance, obtained by dissolving iron containing carbon, has been

up only with difficulty by long boiling in strong nitric acid or chlorate of potash and hydrochloric acid.

The following analyses have been made of this iron from Ovifak:—

I. Analysis of a fragment from one of the large stones, by A. E. Nordenskiöld. II. Analysis of a specimen of more compact iron, by Th. Nordström. III. Analysis of iron with conspicuous Widmanstättian figures from the basalt ridge by G. Lindström.

	I.	II.	III.
Iron	84·49	86·34	93·24
Nickel	2·48	1·64	1·24
Cobalt	0·07	0·35	0·56
Copper	0·27	0·19	0·19
Alumina	hardly perceptible	0·24	——
Lime	hardly perceptible	0·48	——
Magnesia...	0·04	0·29	some traces.
Potash	scarcely enough to weigh.	0·07	0·08
Soda...	scarcely enough to weigh.	0·14	0·12
Phosphorus	0·20	0·07	0·03
Sulphur	1·52	0·22	1·21
Chlorine	0·72	1·16	0·16
Silicic acid	scarcely perceptible	0·66	0·59
Insoluble portion	0·05	4·37	0·59
Carbon, Organic matter, Oxygen, and Water (loss)	10·16	3·71	C. 2·30 H. 0·07
	100·00	100·00	99·79

I. Contained scarcely any traces of silicic acid, alumina or lime. The iron was therefore entirely free from silicates, although large lumps of basalt were firmly rusted on to the surface of the meteorite, and one or two fragments of basalt surrounded with iron could be observed within the iron near the surface. Even before heating to redness, I. emitted a good deal of water and gas, as much apparently as amounted to about 100 times the volume of the iron,—that is to say, considerably more than the iron examined in Analyses I. and II. This explains the large loss in I. The specific gravity of I. was ascertained, from two (porous) fragments of some grammes weight, to be 6·36 and 5·86. The smaller specific gravity here arises evidently from the large quantity of carbonaceous matter that is contained in this iron. Nordström obtained the specific weight of II. from two experiments on small pieces = 7·05 and 7·06. Lindström found the specific gravity of III. at 17° C. to be equal to 6·24. The iron employed in Analysis II. was less crystalline and more compact than that used in Analysis I. It was hard to break, and small grains could be hammered flat without disintegration. In Analyses II. and III. the materials examined were in external appearance precisely alike, and I

mentioned by Berzelius, in *Afhandl. i Fysik, Kemi och Mineralogi.* When iron containing carbon is dissolved in hydrochloric acid of proper strength and temperature, not only is this humus-like matter generated, but hydro-carbons also, and (according to a statement made to me by Prof. Eggertz) even fluid hydro-carbons, the atomic composition of which is very complicated. We have here, then, a method for attempting the synthesis of organic substances from their inorganic components unemployed hitherto, as far as I am aware, in synthetic organic chemistry. *Iron containing carbon was pointed out by Berzelius in* 1818 (Aph. i. Fysik, Kemi, etc., vol. v. p. 534) *as an inorganic material which might serve as a means for the synthetical formation of organic compounds.*

therefore consider it as probable that the material of II. also was from the basalt ridge, although it had afterwards crumbled apart.

IV. Analysis of the silicate that remained undissolved in Analysis II. by Dr. Th. Nordström. V. Analysis of a piece of basalt firmly rusted on to the surface of the largest meteorite, by Dr. Th. Nordström.

	IV.		V.
Silicic Acid	61·79	...	44·01
Alumina	23·31	...	14·27
Sesquioxide of Iron	1·45	...	3·89
Protoxide of Iron	—	...	14·75
Magnesia	2·83	...	8·11
Lime	8·33	...	10·91
Potash (loss included)	2·29	...	0·97
Soda (loss included)			2·61
	100·00	...	99·52

VI. and VII. Analyses of the carbonaceous matter in the iron of II. by Nordström, 33·0479 gr., gave after first treating with chloride of copper, and afterwards with chloride of iron, 4·79 per cent. of a carbonaceous matter, containing 42·58 per cent. ash. An elementary analysis of this carbonaceous matter, deducting the ash, gave—

	VI.		VII.
Carbon	63·59	...	63·64
Hydrogen	3·26	...	3·55
Oxygen (loss included)	33·15	...	32·81
	100·00	...	100·00

The substance is not soluble in either alcohol, ammonia, or potash, and evidently consists of a mixture of organic matter, water and carbon.

The discovery at Ovifak is remarkable, not only as the largest discovery of meteoric iron hitherto known to have been made, but also as that which is richest in carbon, excepting the carbon powder that fell at Hessle. Add to this, the remarkable circumstance, partly that lenticular and discoidal pieces of native iron occur *at the same place* in the underlying basalt, partly that basalt pieces of considerable size, in numerous spots, form a crust on the larger meteorites, and are even sometimes met with driven through the surface into the iron. Nevertheless, in spite of this, it appears to me that there cannot be a doubt of the really meteoric origin of the large masses. Their form, their composition, their appearance, sufficiently indicate this. To explain the occurrence of meteoric iron together with basalt we must then assume:

(1) Either that the ridges FG and GH (see map[1]) are only apparently in solid connexion with the rock, but are really only fragments of one large meteorite of 20 to 40 feet in diameter, formed principally of a mass of basalt-like matter, with balls of iron disseminated through it, that has fallen at this spot. This assumption would, however, be too hazardous, and is rendered improbable by the circumstance that the basalt that surrounds the meteoric iron is perfectly similar to the exact variety of the Greenland basalt, which forms the rocks of the

[1] Published with Part II. in the August number, p. 355.

locality.[1] The greatest part of the stone mass into which the iron particles are scattered is, however, very unlike genuine basalt, and in external appearance rather resembles the meteoric stone from Tanacera Pass, in Chili. Time has not yet permitted a more accurate investigation.

Or, (2) that the whole fall of meteoric iron took place during the period when the piling up of these Greenland basalt rocks was in progress, *i.e.* during the latter portion of the Cretaceous and the beginning of the Tertiary periods. Some of the pieces of meteoric iron have fallen to iron-dust, and filled cracks in the basalt, where they have again hardened into the iron above described as found in the ridge FG. Of similar origin are also the particles of native iron in the basalt lying nearest the iron, which occasionally has a conglomerate-like structure.

As considerable masses of iron, of a composition probably very similar to that of meteoric iron, without a doubt occur in the interior of the earth, it may be suggested that the Ovifak iron may be of telluric origin, and that it has been, together with the plutonic rocks, thrown up during the eruptions that have given rise to the vast strata of basalt in this neighbourhood. But not only does the fully marked meteoritic form of the many iron pieces militate against this supposition, but also the circumstance that the iron in question—as the facts of its containing organic matter, its porosity etc., show—*has evidently never been heated even to a temperature of a few hundred degrees.*

Neither is it possible that these masses of iron can have arisen from the reduction by gases developed in connexion with basalt eruptions of a ferruginous mineral. Iron pyrites cannot be reduced by these means, while no oxide-of-iron-mineral containing nickel, and at the same time almost free from lime and silica, is known. The formation of the iron from chloride of iron, which had been erupted from the interior of the earth and since been reduced, can hardly be supposed. The explanation I have given above, that the iron is the result of an unusually rich Miocene fall of meteoric iron, seems, therefore, to me most plausible.

Öberg also was fortunate enough to meet with a piece of meteoric iron from the neighbourhood of Jakobshavn. He received the piece, which weighed 7½ Skålpund (7℔ Avoird.), from Dr. Pfaff, of Jakobshavn. This piece, which is now preserved in the Riks Museum at Stockholm, is an oval lump, with a somewhat rough surface, consisting principally of very hard, tough, not crumbling iron. On being sawn through, it presented the appearance of a mass of iron grains welded together, here and there impregnated with a basalt-like black silicate. On etching, fine Widmanstättian figures are obtained. We have not had time to analyse it, and I need not therefore dwell longer on the description of it, especially if, as is greatly to be wished,[2] the three larger iron blocks left at Ovifak

[1] Only the basalt in some parts of the ridge FG and GH, but not the basalt from other districts of Disko and Noursoak, does contain native iron.

[2] As I have above mentioned, the Swedish Government sent for this purpose

should be brought home, in which case I shall be enabled to give a complete account of all the Greenland discoveries of iron, together with more analyses. I will here simply enumerate the discoveries of iron hitherto made on the western coast of Greenland.

(1). *Ross and Kane's discovery of iron in Davis Strait.*—According to these famous polar navigators, the Esquimaux in North Greenland make knives and instruments of iron from some large blocks situated probably somewhere to the north of Upernivik.

(2). *Rink's discovery of iron at Niakornak, Jakobshavn District.*—In 1847 Rink found in the possession of some Greenlanders an iron ball, which they said they had found in a plain covered with boulders near the mouth of the Anorritok River. It weighed 21℔, with a specific gravity of 7·02. Analysed by Forchammer. Crumbling scarcely perceptible.

(3). *Rudolph's discovery of iron at Fortune Bay.*—A piece of iron weighing 11,844 gr. was found by Colonial Governor Rudolph among ballast that had been taken in at Fortune Bay. The iron crumbles much, and belongs probably to the same fall as the iron found at Ovifak.

(4). *Fiskernäss.*—A small piece of metallic iron was found by Rink at Fiskernäss in South Greenland. The iron was declared by Forchammer to be of meteoric origin.

And lastly:—

(5). *The Pfaff-Öberg iron from Jakobshavn.*

(6). *The iron discovered at Ovifak.*

Lastly it should be mentioned, that the old northern chronicles state, that during the time the old colonies existed in Greenland, so violent a shower of stones once happened that several churches and other buildings were destroyed.

It is remarkable that Giesecke, in his many years of travel in Greenland, should not have met with any meteoric iron, whereas he mentions that huge balls of iron pyrites were found in the sand-beds of the basalt formation. We also met with some such balls at an elevation of a couple of hundred feet above the sea, between Ujarasusuk and Kudliset. They were as much as from 3 to 4 feet in diameter, spherical, and lay loose in the sand close to a basalt dyke. Nevertheless, they did not contain pyrites, but a mineral (not yet analysed) like magnetic pyrites of a very unusual appearance.

In our excursions round Disko Bay and the Waigat, I availed myself of such opportunities as offered themselves for astronomical determinations of localities. These have since been calculated by Mr. Edward Jäderin, and a detailed account of them will hereafter be published. Here I shall only append a table of the results of the calculations, together with a copy of a part of Rink's map of North Greenland, corrected according to these geographical determinations,

an expedition to Greenland, 1872, which succeeded in bringing home not only the three meteorites of 21, 8, and 4 tons, but also several smaller ones of from 4 to 200 kilogr.

and a small number of angular measures. The places whose positions were astronomically determined by us are on the map marked with a cross. Spots where fossil plants were discovered are distinguished by a different mark.

Geographical Determinations made in the Expedition of 1870, calculated by E. Jäderin.

	N. Lat. ° ′ ″	Long. from Godhavn. ° ′ ″	Long. from Greenwich. ° ′ ″
Godhavn, our place of residence	69 13 57	———	53 24 0 W.[1]
Egedesminde, Colonial Gov. house ...	68 42 9	0 37 36 E.	52 46 24 „
Kangaitsiak, Emissary's (Utliggares) Residence	68 18 19	0 3 57 „	53 20 3 „
Narrow place on the Northern strand of Auleitsivik	68 10 43	1 9 51 „	52 14 9 „
Site of old house on the northern strand of Auleitsivik	68 16 23	1 55 42 „	51 28 18 „
Island in Tessiursarsoak	68 16 58	2 13 48 „	51 10 12 „
Place of our tent beside Tessiursarsoak	68 20 50	2 17 43 „	51 6 17 „
Landing place, south side of isthmus at Sarpiursak	68 25 36	1 51 29 „	51 32 31 „
Ditto north side ditto	68 29 49	1 48 10 „	51 35 50 „
Christianshaab. Colonial Gov. house...	68 48 34	2 15 46 „	51 8 14 „
Kaja, inner extremity of Jakobshavn ice-fjord	69 7 26	2 43 0 „	50 41 0 „
Mudderbugt, deserted house	69 38 7	1 32 12 „	51 51 48 „
Ujarasusuk, Emissary's (Utliggares) Residence	69 51 2	1 4 54 „	52 19 6 „
Atanekerdluk, south of the low isthmus	70 2 30	1 8 57 „	52 15 3 „
Waigat, eastern shore near Mannik ...	70 10 1	0 55 14 „	52 28 46 „
Ditto south of Atane River ...	70 15 20	0 37 51 „	52 46 9 „
Noursoak, Emissary's Residence	70 40 4	1 4 25 W.	54 28 25 „
Niakornet, Emissary's Residence	70 46 46	0 5 52 „	53 29 52 „
Karsok, Emissary's Residence	70 43 28	0 53 36 E.	52 30 24 „
Pattorfik. Sea-shore 400 feet south-east of mouth of river	70 42 6	1 2 51 „	51 21 9 „
Omenak, New Col. Government house	70 39 53	1 25 11 „	51 58 49 „
Kome, deserted house	70 37 18	1 15 16 „	52 8 44 „

It was hardly compatible with Dr. Berggren's and Öberg's botanical and zoological interests to participate in the long, tedious, boat excursions Dr. Nordström and I intended to make round the shores of Disko Island and Noursoak peninsula, and accordingly, as above stated, after the excursion to Kaja, our little expedition divided itself into two parties on the 31st of July. The proceedings of the one party I have already related: concerning those of the other, Dr. Berggren has made the following communication :—

"It was Aug. 1, at 5 A.M., that we took leave of each other, Prof. Nordenskiöld and Dr. Nordström to proceed to the peninsula of Noursoak, Dr. Öberg and I to continue our zoological and botanical researches up to the mouth of the Waigat. Claushavn, which formed our principal station from the 1st to the 13th of August, offered—on account of the roominess of the Colonial Governor's house, which was placed at our disposal—a convenient place for arranging and preserving the collections made in the previous boat excursions, but which it had previously been impossible to treat with sufficient care.

[1] According to Graah's determination.

For the purpose of dredging, for which two crews were sometimes employed, new men were obtained from Claushavn, and those we had hitherto employed were dismissed home. The country round about the colony is a plain rich in flowers, surrounded by hills of only a few hundred feet high, with a fenny moor-land soil, and a small lake in the middle. This, like other lakes in the neighbourhood, was interesting both in zoological and in botanical respects, on account of three phanerogamous plants, not previously met with in Greenland, being there found. As the stay of nearly two weeks which we made here happened just when the phanerogamic flora—which, in consequence of the varied nature of the ground, is here very richly represented—is in its fullest flower, and as moreover the moss-flora, for the same reasons, is one of the richest in the gneiss-regions, and the dredgings brought in a number of marine algæ, the botanical collection made at Claushavn forms a considerable part of the whole.

"We left Claushavn in the afternoon of the 13th of August, and after three or four hours rowing, passed the ice-stream, just at that moment giving off its ice into the sea, to Jakobshavn. In consequence of the vicinity of that colony to the ice-stream, the dredging here produced an interesting collection of marine animals, as well as of algæ, among which was the *Laminaria solidungula*, previously only known as belonging to Spitzbergen. The ruins and dirt-beds at the old deserted site of Sermermiut were examined, and both from thence and other places a number of flint tools were collected. The country immediately around the colony consists of low rounded hills, but further inland lies a tolerably extensive plain, with marshy soil and some lakes, which is again inclosed by higher mountain ridges. This likeness to the environs of Claushavn causes the vegetation at the two places to be generally of a similar nature.

"Aug. 19. At 11 A.M. we left Jakobshavn, and steering our course northward, arrived in the evening at the mouth of Illartlek. After passing through the narrow entrance to that fjord, inclosed on either side by lofty cliffs, where there is a very strong current, we encamped at 11 P.M. beside a little calm harbour in the peninsula, which separates the two arms of the gulf.

On the 20th and 21st dredgings and botanical excursions were made into the inner part of the gulf, extending nearly up to the inland ice. It was from this point that Whymper and Brown ascended the inland ice in 1867. I occupied myself principally with examining the vegetation of the mountain tops, which do not here usually exceed 1000 feet in height. Instead of the fine weather which had hitherto favoured us, on the 21st of August it began to rain, which hindered our work, and the rain flowed down in such quantities from the mountain slopes over the spot where our tent stood, that we were obliged to leave. To get under cover we first rowed to the Greenlanders' houses at Pakitsok. Rain and contrary winds detained us in these cottages (uninhabited during the summer) till the afternoon of the 23rd of August, when we departed for Ritenbenk, where we arrived in the night between the 23rd and 24th of August.

"In contrast to the southern side of Disko Bay, the mountains on the northern side, about Illartlek and Arveprindsens Eiland, sometimes attain a height of 2000 feet, and frequently terminate towards the sea in perpendicular walls. In consequence of this greater height, the snow lies there longer in the summer, which gives rise to a constant moisture on the hill-slopes; and these two circumstances produce a landscape and a vegetation of a character different from those of the more southern regions. Several of the valleys on Arveprindsens Island, as well as their fresh-water lakes and surrounding mountain heights, were visited by us. From Ritenbenk we undertook (Aug. 29th, Sept. 1st) a boat excursion to Kikertak Island, in the interior of a fjord on the southern part of Noursoak peninsula. Dredgings were made in the water, here chilled by the ice-stream of Tossukatek, and excursions were undertaken along the hill-slopes of Noursoak peninsula to Majorsoeitsiak, with the view of studying the vegetation of that desolate locality, where belts of inland ice extend in the form of glaciers into the valleys, which in many parts are almost bare, covered with stone boulders, and with little lakes at the bottom.

The vessel "Rjukan," hired by the Danish Trade, had, on the 28th of August, arrived at Ritenbeuk, and, as the time for our return home was fast approaching, we sailed on the 7th of September by that vessel to Godhavn, where Nordström had already arrived. The botanical and zoological excursions, which on our former visit to this place in July had been interrupted by the preparations for boat journeys, were now resumed, while the vessel lay at Godhavn to unload and reload.

"Frequent falls of snow announced the approach of winter. On the 18th September the "Rjukan" weighed anchor for Sukkertoppen (the Sugar-loaf), in South Greenland. When, on the 22nd of September, we reached that colony, the winter had already commenced, and snow a foot deep covered the ground. Though the vessel cleared by the 4th of October, we were detained, by contrary winds and the consequent failure of our repeated attempts to get out of the harbour, till the 21st of October. Favoured during the rest of the voyage by a fair wind, which for some days on the Atlantic rose to a storm, we arrived at Kleven, in Norway, on the 11th of November, whence we started by steamboat, and arrived at Gothenburg on the 17th of November."

REVIEWS

I.—The Physical Geology and Geography of Great Britain. By A. C. Ramsay, LL.D., F.R.S. Third Edition. 8vo., pp. 349. (London: Stanford.)

As a true philosopher ought to subordinate everything to his love of truth, one of his principal characteristics must ever be a tendency to change opinion with the progress of discovery, without regard to his reputation for consistency. Among the great living philosophers whose opinions have changed on many important subjects, we must include Professor Ramsay. It is true that such changes of opinion are not calculated to inspire the outside world with confidence in the latest conclusions at which geologists may arrive, but the answer to this is simply that it cannot be helped. We must not, however, overlook the historical fact that it is possible for a philosopher to alter his opinions for the worse as well as for the better, and even to change his ideas to such an extent as to bring him back to the point whence he set out.

The late Earl Rosse, a truly great man, commenced his observations in the belief that there are many nebulæ incapable of being resolved with the most powerful telescopes; in other words, that there are nebulæ strictly so called in addition to distant nebulous-looking clusters of stars. By and bye, however, he happened to separate a number of the most hazy-looking nebulæ into discrete stars, and this led him to conclude that with instruments of sufficient space-penetrating power all nebulæ might be separated or resolved. After his death, however (if not before), by a new and independent method of observation, in connexion with the adaptation of the spectroscope to the telescope, the theory of the stellar nature of all nebulæ was dissipated, and astronomers were brought back to the old doctrine of La Place and Herschel I., namely, that there are many diffused nebulosities in which a process of condensation into suns and planets has either not commenced or is more or less advanced. Nor is this somersault to which nebular astronomy has been subjected altogether without a parallel in what may yet be found to have been a chapter in the annals of geology.

Many years ago the author of the work before us made a survey of South Wales, with a special reference to the effects of DENUDATION. He noticed the fact that the ravines excavated by the present fresh-water streams exhibit an abrupt commencement on a pre-existing form of ground consisting of plateaux, escarpments, wide valleys, and passes. This partly led him to conclude that the broader and more open depressions must have been left by the sea, and that the great escarpments of the Black mountain, and the Brecon and Caermarthen Fans, were formed by the "Atlantic breakers" during one or more submersions of the land. In his Survey Memoir on South Wales the marine theory is ably advocated and beautifully reasoned from the premises assumed, namely that *sea-waves* are capable of producing the above effects. It would appear that a more extensive acquaintance with the mode of wave-action on coasts must have partly led Professor Ramsay to see the truth of the great and important doctrine that littoral wave-action generally tends to form "plains of marine denudation" by shaving off the summits of eminences as they are trying to emerge from the waters, or by wearing back cliff-lines while the land remains at a stationary level, or while it is slowly and uniformly rising—in the latter case causing *inclined* plains of denudation; and though it follows from this theory that escarpments must have been left where the planing action of the sea left off (and it is simply incredible that all the escarpments so left should since then have vanished, while so many terraced plateaux and table-lands have remained), the discovery of escarpments in the softer or more vertically varied formations which pertinaciously *follow the strike* of the beds, coupled with the fact that the strike is generally ignored by littoral marine action, naturally led to the belief that such escarpments were formed by an agency which is either free to run along, or only capable of running along, the soft outcropping strata. It was likewise clearly perceived that littoral marine action cannot originate narrow valleys which ramify from lower to higher levels. It is not, therefore, surprising that the school of geologists led by Professor Ramsay should have found themselves driven to the agency of "rain and rivers" as the only resource left, more especially as "the inimitable Playfair" long before, and Greenwood and Jukes at a later period, had ably applied the rain-and-river or subaërial theory to the explanation of longitudinal valleys and transverse gorges.

It is very obvious that the subaërial theory has been partly founded on the belief that no agency excepting rain and rivers will explain the phenomena above specified. This theory takes for granted that there is "no wasting action" under the surface of the sea (see p. 69 of the work under review). But as the spectroscope proved the existence of gaseous nebulæ after the idea had been rejected on astronomical grounds, so discoveries connected with hydrodynamical science are now beginning to show that denudation must take place not only at small depths beneath the surface, but at the bottom of deep seas. It is impossible for cold, dense under-currents, such as those brought to light by deep-sea dredgings, to impinge on the sea-bottom, without exerting a wasting influence; and as none of these currents are probably violent enough to wear away soft and hard parts alike, or to ignore the strike of submarine strata, we may reasonably conclude that they are capable of doing much of what has been theoretically attributed to the diffused action of rain, and a part of what has been referred to rivers. But admitting that many broad excavations, troughs, and passes, were slowly *wasted* out, and escarpments left, before the land rose above the sea, we can no longer dispute that rain-torrents, rivers, and ice have since then modified the surface of the land to a very great extent.

In the work before us the *enormous extent of the denudation* to which Great Britain has been subjected is clearly proved by sections and arguments, and this part of the work is especially valuable. The *cause* of the denudation resolves itself into the comparatively unimportant question of *fresh* or salt water. Though many will not agree with Professor Ramsay in his preference for fresh water, all will admire his beautiful explanation of the manner in which the denudation has been achieved; and in connexion with this subject his work contains some very important original contributions to geological science.

We have said so much on denudation, that we have little space left to notice the work in detail. The first four chapters are on the Classification of Rocks, the Ages and Successive Deposition of Stratified Formations; Synclinal and Anticlinal Curves; Denudations by Mechanical and Chemical Action; Metamorphism, Shrinkage, and Disturbance of the Earth's Crust, etc. These chapters include the elements of geology, written in an easy and very readable style. As might be expected, they come thoroughly up to the present state of the science; and as every small text-book on geology with which we are acquainted is very far behind the present state of the science, we should like to see these chapters printed and sold separately. The tendency among elementary compilers to place granite and the metamorphic rocks at the base of the stratified formations is here strongly negatived; and the ill-founded tendency still lingering among many well-informed geologists to refer inclinations and contortions of strata, and the elevation of mountain chains, to "direct igneous action operating from below," is as clearly exposed. "As the earth cooled and gradually shrunk in size, the hardened crust, in its efforts to accommodate itself to the diminishing bulk of the cooling mass within, became in places crumpled again and again . . . . along lines more or less irregular, producing partial upheavals." pp. 48, 43.[1]

The greater part of the work is on the stratigraphical structure of Great Britain, especially England and Wales. The glacial and post-glacial epochs come in for three chapters. The author still believes in the submergence of North Wales to a vertical extent of at least 2,000 feet, but he assigns a greater thickness to the land-ice than he formerly did. He now believes (and we do not see how any one well acquainted with the subject can divest himself of the belief) that the mountains of Scotland, Cumberland, etc., were "literally buried in ice." The limited space allotted to the subject of drift-deposits did not permit the author to enter much into detail; but the reader, nevertheless, cannot fail to be delighted with the mass of varied and wonderful information concerning the Post-tertiary history of our planet to be found between p. 136 and p. 194. Chapter xiii. is on British Climates, Rainfall, and Areas of River Drainage. Chapters xiv. and xv., on the Origin and Dates of River-valleys and Gravels, are the most original in the book, and will afford a capital exercise for the reasoning faculties of the well-informed reader. Chapters xvi. and xvii. are on practical and economical subjects, namely, the Qualities of River-waters and Soils. The great variety of topics contained in the work is ultra-varied by a chapter on the Relation of the Different Races of Men in Britain to the Geology of the Country. The last chapter is on the Origin of Lodes, the Origin, Extent, Form, and Duration of Coal-fields (with a beautiful section across the Pennine Hills), the Economic Uses of Iron-stones, Clays, and Chalk-flints, Building-stones, Rock Salt, Gypsum, etc.

We fear we have given the reader but a very imperfect idea of the varied and important contents of Professor Ramsay's work. It must be read to be fully appreciated. It will, no doubt, be in the library of every true geologist, and it ought to be in the library of every

[1] The distension consequent on upheaval would cause fractures by which the direction of subsequent denudation would be guided; but unless the fractures were very large, or accompanied by faults, it would be unreasonable to look for traces of their existence in the valleys supposed to occupy their places. Professor Ramsay is of a different opinion. See p. 116.

schoolmaster and schoolmistress in the kingdom, and, we might add, every landed proprietor. The beautifully coloured Geological Map of Great Britain, at the commencement of the volume, is worth at least half the price of the work, which is only 7*s.* 6*d.* This edition may almost be regarded as a new work. D. M.

II.—Proceedings of the Bristol Naturalists' Society, vol. vi., 1871.

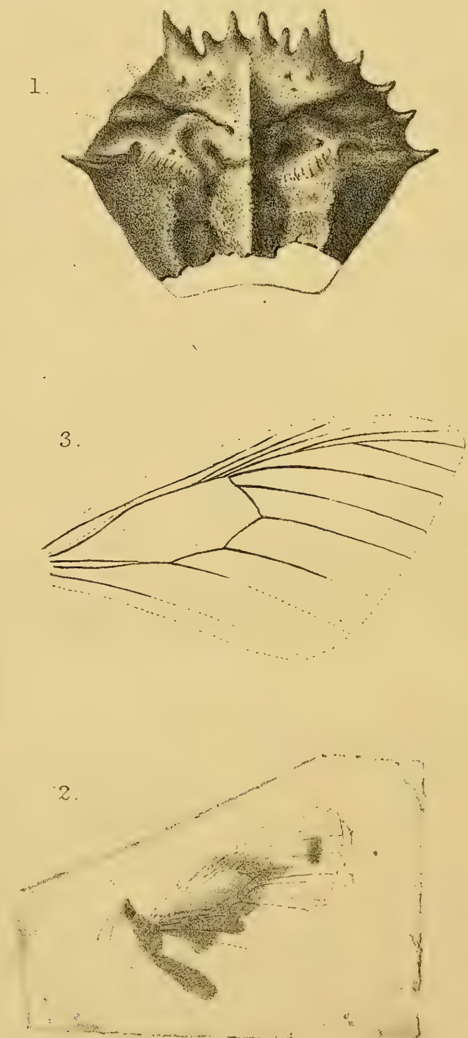
We generally look to our local societies for observations on the Natural History of the neighbourhood which it is their special province to investigate—indeed most of them were formed for this purpose. Our Bristol friends last year, however, seem to have found nothing new to say about their own country, and so the only geological papers relate to distant parts,—the valley of the Thames in Berkshire, the shores of Waterford Haven, and the neighbourhood of Edinburgh. We think it is rather a mistake to publish such papers in the journal of a local society; we do not mean to discourage the bringing together of facts from other parts: but if the paper be a record of any new facts, it is apt to be lost sight of and is unknown to those who would perhaps be specially interested in it.—Fort-Major Austin read a paper on his discovery many years ago of Silurian fossils at Duncannon, Wexford, which were identified by Mr. Salter as belonging to the Llandeilo Flags.—Mr. E. W. Claypole read a paper on the development of the Carboniferous system in the neighbourhood of Edinburgh; and another on some Gravels in the Valley of the Thames near Wallingford, in Berkshire.

CORRESPONDENCE.

THE DIVINING-ROD IN SOMERSETSHIRE.

Sir,—One would imagine that the Divining-rod or Dowsing fork had become a thing of the past—that in these "enlightened" days, no man could go about with a forked hazel-twig pressed to his ribs, and believe it could indicate a coal-crop, a metalliferous deposit, or a water-supply. Yet there are some who still cling without question to the faith of their fathers, on the principle that as it was in the beginning it should be now, and so although I experienced a sensation of great surprise, and almost of incredulity, yet the fact appears that on the Mendip Hills the Divining-rod is still used. I was staying a few days ago at the little hamlet of Gurney Slade, near Oakhill, and went to look at a shaft that was being sunk for iron-ore, not far from the decayed George Inn. Several trial holes had been made—and some I was told by an intelligent miner had been made at the instigation of the Divining-rod! Although a little iron had been found, and some calamine too,—both of which would most probably be found anywhere in the Dolomitic Conglomerate of the Mendips,—yet the ores were very poor, and the works would no doubt soon be abandoned. I have heard that a few of the old Cornish miners still retain some belief in the efficacy of the Divining-rod, but I was not prepared to find it still being used as a guide to mining enterprise. H. B. Woodward.

Somerton, 12*th October*, 1872.



G.R. De Wilde del et lith. W. West & Co. imp.

Fig. 1. *Orithopsis Bonneyi, J. Carter, U. Greensand. Lyme Regis.*
Figs. 2 & 3. *Satyrites Reynesii, Scudder, Tertiary, Aix in Provence.*

THE

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ORIGINAL ARTICLES.

I.—On *Orithopsis Bonneyi*, a new Fossil Crustacean.

By James Carter, M.R.C.S., etc.

(PLATE XIII. FIG. 1.)

IN a paper, "On the Geology of the South Coast of England," published in the Transactions of the Geological Society, vol. i., 2nd ser., pl. iii., fig. 2,[1] p. 42, Sir H. de la Beche has figured a crustacean from the Greensand of Lyme Regis, to which he has not applied any name, or given any other description than that it is "the back of a singular fossil crab." The specimen is imperfect, and not very accurately drawn; but Prof. Bell, in his monograph, published by the Palæontographical Society (1862), expresses his opinion that it is an "unmistakeable figure" of *Necrocarcinus tricarinatus*.

A crustacean from the Gault of Folkestone is figured and described by Mr. Woodward in the Geological Magazine, Vol. V., Pl. XIV., Fig. 4, p. 259, which he regards as also a specimen of *N. tricarinatus*. Unfortunately the anterior portion of the carapace is broken, and does not exhibit the important characters of the orbito-frontal region.

The well-preserved specimen from the Greensand of Lyme Regis, figured in Pl. XIII., Fig. 1, has been recently added to the Woodwardian Museum at Cambridge, and I have a smaller one from the same locality in my own collection.

There cannot, I think, be a doubt but that the crustacean figured by Sir H. de la Beche and by Mr. Woodward, as also the specimens from Lyme Regis, are all examples of one and the same species. It is, moreover, evident, as Mr. Woodward observes, that this species is generically distinct from *Necrocarcinus Woodwardii* and *N. Bechei*. I would add that it is equally distinct from *N. tricarinatus*. Indeed, so far as I know, it is not referable to any described genus. I therefore propose to establish a new one, which I would designate

[1] Not fig. 1, as stated by Mr. Woodward and Prof. Bell in their respective papers.

Orithopsis, from the apparent affinity to the recent *Orithyia*. I dedicate the species to the Rev. T. G. Bonney, of St. John's College, Cambridge, whose active interest in the advancement of geological science is attested by his frequent and valuable communications to this and to other scientific journals.

In general form this species has so great a resemblance to *Necrocarcinus tricarinatus*, as at first sight to suggest the probability that the difference may result from better preservation than usual. Closer examination, however, shows that the two species are really distinct, and that the modification of character cannot be attributed to attrition or any other accidental cause. Most of the fossils from the Cambridge Greensand are more or less worn, and the degree to which this has occurred may be determined by comparing them with specimens from other localities. The distinctness of the two forms would, moreover, seem to be conclusively proved by the occurrence of both of them in the same "gisement"—the Gault of Folkestone, as I recently discovered among the series of fossils from that locality in the Woodwardian Museum, several specimens of *N. tricarinatus*, precisely identical in character with the Cambridge and Wiltshire forms. A careful examination of a series of some fifty specimens convinces me that *N. tricarinatus* is a good species, and that, so far as its details are known, it is properly classified with *N. Woodwardii* and *N. Bechei*.

Orithopsis differs from all the species of *Necrocarcinus* by the conformation of the rostrum and of the orbital regions, as also by the greater development of the spines of the antero-lateral margin. These characters can scarcely be regarded as of mere specific value, inasmuch as they are modifications of normal and typical points of structure, and therefore have a morphological signification of such importance as to warrant generic interpretation in classification. It is almost impossible to assign the zoological affinities of the genus with any precision, as the structure of the mouth, abdomen, and limbs is unknown, and consequently we have no knowledge of the important functions of nutrition or locomotion. So far, however, as the characters of the carapace will indicate, the affinity, as Mr. Woodward has remarked, is rather with the *Portunidæ* than with the *Corystidæ*. The orbito-frontal characters are very similar to those of *Orithyia*; but the armature of the antero-lateral margin—especially the well-developed metabranchial spine—approximates *Matuta*. The zoological position of *Orithopsis* would appear to be between these two genera.

The physiological signification of that remarkable character—the carination of the metabranchial lobes—has yet to be determined; but that it cannot be regarded as of specific value only is demonstrated by its occurrence, either as a ridge, or as a row of tubercles, in several other London-clay genera—*Portunites, Campylostoma, Rhachiosoma*, etc.

It is worthy of observation that in *Orithopsis* the marginal armature is well developed, but the large dorsal tubercles are almost obsolete; in *Necrocarcinus*, however, the reverse occurs—the dorsal tubercles being more developed than the marginal spines. This fact is of interest as an indication that there is a difference in the morphological signification of these respective characters.

Description.—Generic characters:—Carapace rather wider than long, rostrum bifid, orbits opening forwards, orbital lobes well developed, antero-lateral margin with acute spines, gastric regions obscurely defined, branchial regions distinct, metabranchial lobe longitudinally carinated.

Orithopsis Bonneyi (Carter).—*Dorsal surface* of carapace considerably arched transversely, less so in the direction of the mesial ridge; minutely granulated, and still more minutely punctated. *Antero-lateral margin* rounded, rendered irregular by the unequal prominence of the hepatic and anterior branchial lobes. A well-developed, acute, slightly-curved *marginal spine* arises from the hepatic and from each of the branchial lobes, that from the anterior angle of the metabranchial being the larger; a fifth—the stoutest of the normal series—is constituted by the external orbital lobe. *Postero-lateral margin* nearly straight, inclining inwards so as to render the posterior about equal to the orbito-frontal border. *Rostrum* broad, widely bifid, divided into two stout, slightly-diverging lobes. *Orbits* opening forwards, bordered above by two distinct superciliary lobes, which are separated from each other by a deep sinus and from the external orbital lobe by a sharp fissure; the external angle of orbit much produced, extending nearly as far forwards as the rostral spines; all the orbital spines are directed horizontally forwards and outwards. Orbito-frontal region measuring rather less than half the greatest width of the carapace. A distinct sinuous sulcus separates the anterior gastric and the hepatic from the branchial regions, but does not cross the dorsal carina, ceasing abruptly at the point of junction of the meso- and metagastric lobes; a sulcus completely separates the posterior gastric from the cardiac regions. *Branchial regions* sharply defined; a triangular epibranchial terminates about midway between the margin and the median dorsal ridge, and is marked off from the mesobranchial lobe by an undulating sulcus; a similar and nearly parallel groove—the inner half of which is obliquely crossed by a series of elongated foveæ—divides the meso- from the metabranchial lobes. The metabranchial and cardiac lobes occupy the larger posterior half of the carapace; a prominent, granulated, longitudinal ridge, slightly inflected in the middle, carinates each metabranchial lobe. A median carina marks the anterior two-thirds of the carapace, extending along the gastric and cardiac regions. There are a few faintly-marked large tubercles, of which two occur on each protogastric, one on the inner portion of the mesobranchial lobe, and three or four on the median ridge; those on the metabranchial carina scarcely distinguishable.

Length of carapace $1\frac{1}{4}$ in.; width (not measuring marginal spines) $1\frac{3}{8}$ in.

Localities.—Upper Greensand, Lyme Regis, and Gault, Folkestone.

The following differences of character will distinguish this species from *Necrocarcinus tricarinatus*:—

Orithopsis.	*Necrocarcinus.*
Rostrum bifid.	Rostrum acute, triangular.
Orbits looking forwards; orbital lobes well produced.	Orbits open above; orbital lobes rather small.
Antero-lateral border with acute spines, of which the metabranchial is the largest.	Antero-lateral border with short, stout spines, of which the mesobranchial is the largest.
Width of orbito-frontal region not exceeding half the greatest width of carapace.	Width of orbito-frontal region exceeding half the greatest width of carapace.
Large dorsal tubercles indistinct.	Large dorsal tubercles distinct.

II.—Description of a New Fossil Butterfly [1] (*Satyrites Reynesii*), found at Aix in Provence.

By Samuel H. Scudder, Esq., of Boston, U.S.

(PLATE XIII., FIGS. 2 and 3.)

During a recent visit to the Marseilles Museum, and while examining the rich collection of fossil insects preserved there, my attention was attracted by two specimens of the remains of a fossil butterfly. Although not very well preserved, nor indeed so perfect as the specimen of a fossil butterfly from the same formation, which was described thirty years ago by Dr. Boisduval, it was evident, at first sight, that the remains in question belonged to a different species, since the lateral moulding of the principal wings was very much inflated.

No similar form having to my knowledge been described from the formation in which this was found, Dr. Reynes, the eminent Director of the Museum, courteously placed in my hands the best specimen, so that I might examine it more attentively. The second specimen is very imperfectly preserved, but nevertheless it undoubtedly belongs to the same species.

The fossil is the natural imprint of a butterfly—the insect being placed on its side, with the wings elevated one against the other, the legs spread out as if it were suspended, the spiral proboscis unrolled, and the antennæ lowered in the same direction as the legs. The first wing on the right, which is found underneath, is slightly turned up and disturbed along its margin, which shows that the specimen has undergone great maceration in quiet water, before being covered up by the deposits which have preserved its most essential features. The condition and the position of all the parts of the fossil lead us to conjecture that it has been carried away to its fixed place of repose by a feeble current, which has left its most slender organs in the direction which it took.

It is evident that the object in question is an imprint, for the mouldings of the uppermost wing are imprinted in a hollow like those which may be observed in the upper part of the wings of the living Satyrides, whilst those on the wing which is below are reproduced in relief, as may be observed on the lower surface of the

[1] Translated from the "Révue et Magasin de Zoologie," 1872.

same butterflies; that is to say, we have here the contrary of what would be produced if we examine a living butterfly in this position.

The parts which we have before us are: a rather badly preserved body, obscure traces of the last palpal articulation, an antenna (or probably a portion of one only), a spiral proboscis unrolled, the two hind legs and portions of others, the greater part of the two first wings, and fragments of the base of the second wings; of these latter all the borders have disappeared, the base only remains of some of the nerves, which furnishes scarcely any additional information on the pterology of the insect. The only portion of the edge of the first wings, which could be accurately determined, is the most essential part; the apex of the left wing and the upper portion of its extreme edge suffice to indicate that its general contour was similar to that of the European Satyrides of the present time; but one could easily follow the traces of each nerve on the whole of the remains.

The essential parts of the first wings are so perfectly preserved, that entire confidence may be placed in the character of the remainder. It is difficult to discover the least vestige of the costal margin on the specimen. One can however determine with almost absolute certainty its points of contact with the costal nervure, and the two first upper branches of the sub-costal nerve.

In regard to the body of the insect, nothing can be said with precision, unless the form of the abdomen and the appearance of its extremity allow of its being considered a female, which had deposited the greater part of its eggs, or in which they were only partially developed.

We propose to call it *Satyrites Reynesii.* The organization of the first wings does not seem to offer a sufficient relation with that of any known genus of Satyrides, to allow of its being classed with them; it has undoubtedly close affinities with the distinctive characters of the genus *Debis* (*Lethe*, Hübn.), as it has been described by Messrs. Westwood and Hewitson, if we except of course the *Papilio Portlandia* of Fabricius. It is interesting to observe that these authors have placed this group just beside the genus *Cyllo* (*Melanitis*, Fabr.), in which Dr. Boisduval placed the fossil species of Aix, which he named *C. sepulta*. Moreover, it is not less interesting to remark that all the living representatives of these two genera are natives of India, so that the insects which approach the nearest to the fossil butterflies of Provence are found in the countries of the East.

EXPLANATION OF PLATE XIII., FIGS. 2 & 3.

Fig. 2. The butterfly as it appears on the stone. Natural size.

Fig. 3. A first wing: twice the natural size. The dotted lines represent the parts reconstructed by analogy.

III.—Note on the Results of some Recent Researches among the Graptolitic Black Shales of the South of Scotland.

By Charles Lapworth, Esq.

In his excellent paper on *New Scottish Graptolites*, published in the last monthly part of the Geological Magazine, Mr. John Hopkinson incidentally refers to the various opinions that have been held by different geologists concerning the thickness and geological age of the carbonaceous Graptolite-bearing shales of South Scotland. He expresses his conviction, derived from a study of the fossils they afford, that there is but "a single band of Graptolite shale, which runs through the *Llandeilo beds* of South Scotland, there being in this band several distinct zones, each marked by a different assemblage of fossils, but with many species in common." [1]

Having devoted considerable attention to these peculiar strata during the last few years, I wish, in anticipation of a detailed paper on the whole subject, to give a very brief summary of the main conclusions at which I have arrived, more especially in reference to those points to which Mr. Hopkinson has alluded.

Professor Harkness, who first called the attention of geologists to these beds, gave it as his opinion that the relations of these Black Shale bands to each other is such as to prove that they were originally portions of the same deposit; and that their present position is probably attributable to a succession of faults, which run through the district in the direction of the strike of the rocks, and have repeatedly thrown down the strata in a N.N.W. direction.[2] He afterwards somewhat modified this opinion, at the suggestion of Sir R. Murchison, and explained their present relations by great curvatures of the strata, the upper portions of which have been denuded.[3] He also believed that the rocks in which these bands are imbedded are the equivalents of the *Caradoc Sandstone;* while Sir R. Murchison considered that they more nearly represent that great mass of Welsh Schist which underlies the *Bala Limestone,* i.e. of *Upper Llandeilo* age.[4]

The latter view of their age has been unhesitatingly adopted by the great majority of Silurian geologists, and it will require no slight weight of contrary evidence to displace it.

The theory of Professor Harkness, that these bands are simply repetitions of one and the same deposit, has gradually given way to another, viz. that there are several distinct bands, or groups of bands, on very different geological horizons, and divided from each other by great vertical thicknesses of comparatively unfossiliferous strata. This latter theory has been lately adopted by the Geological Survey of Scotland. In the carefully prepared "Explanation to accompany Sheet 15," the *Silurian Rocks* of Lanark and the North of Dumfries are arranged in descending order, as follows:—

H. *Caradoc or Bala Beds.*[5]

Llandeilo Beds.

(G.) *Black Shale Group.* 3400 feet.
(F.) *Lowther Group.* 5000 feet.
(E.) *Haggis Rock Group.* 1800 feet.
(D.) *Dalveen Group.* 2900 feet.
(C.) *Daer Group.* Thickness not ascertained.
(B.) *Hartfell (Black) Shale Group.* ,,
(A.) *Queensberry Grit Group.* ,,

[1] Page 501.
[2] Geol. Journ., vol. vii., pp. 51, 52.
[3] Geol. Journ., vii., p. 162; xii., p. 245.
[4] Geol. Journ., vii., pp. 53, 162.
[5] Explanation, Sheet 15, Geol. Surv. Scotland, p. 9. Edin., 1871.

Two distinct groups of Black Shales are here recognized, and they are supposed to be divided from each other by at least 10,000 feet of intervening unfossiliferous strata. The whole series is referred to the *Llandeilo* generally, and the higher Black Shale Group is classed unhesitatingly with the *Upper Llandeilo.*

In a paper read at the meeting of the British Association in Edinburgh, in August, 1871, and which was afterwards published in the Geological Magazine,[1] Mr. Jas. Wilson and myself expressed our belief that there was but a single band of Black Shale, that it lay at the summit of the *Moffat Series*, and probably formed a connecting link between the *Llandeilo* and *Caradoc* formations. A short notice of the general results of my later investigations was given in a paper read before the Geological Society of Glasgow in January last, an abstract of which appears in the present part of the Transactions of that Society.

Subsequent researches have simply more clearly proved the correctness of my main conclusions as there given, which may be thus very briefly summarized:—

There is but a single group of these carbonaceous and graptolitic shales, of from 500 to 600 feet in total thickness. This group, which may for the present be called the *Moffat Shale*, is lithologically and palæontologically separable into three great divisions, viz. the *Lower, Middle,* and *Upper Moffat.* These divisions, which are very different in vertical thickness, each contain a great abundance of *Graptolites;* and though there are probably nearly a hundred different species in all (of which at least one third are as yet undescribed), yet so restricted are they in their vertical distribution, that it is impossible to say at present that there are half a dozen forms which are not peculiar to one or other of these divisions.

The major divisions naturally subdivide into several distinct *zones*, each characterized either by the exclusive possession of some well-marked species, or by the constant presence of some peculiar group of species. These zones are easily recognizable, and furnish exactly the same fossils, in localities as much as forty or fifty miles apart.

The *Lower Moffat* contains the Graptolites of the *Hudson River Group* of America, and those of the *Llandeilo* beds of Portmadoc, and is, in my opinion, of *Lower Llandeilo* age. The *Middle Moffat* appears to be the equivalent of the *Upper Llandeilo* of Builth; while the *Upper Moffat* is decidedly *Caradoc.* The *Moffat Shale*, which in almost every case comes to the surface along anticlines of the strata, passes up conformably into the overlying *Gala Group*, (which belongs to the *Upper Caradoc* and *Llandovery* period) in several localities in the southern districts, but to the north the basement bed of the latter rests usually upon the *Lower Moffat* beds, so that there appears to be in many cases an entire absence of *Upper Llandeilo* and *Lower Caradoc* rocks in that direction, the *Lower Llandeilo* being succeeded immediately by the *Upper Caradoc.*

[1] Vol. VIII., p. 463.

IV.—On the Microscopic Structure of the Pitchstones and Felsites of Arran.

By S. Allport, F.G.S.

IN my last communication[1] I gave some account of all the varieties of Arran pitchstones then known to me, and referring to other closely allied rocks, intimated an intention of describing them on another occasion.

A second visit to the island during the past summer has not only enabled me to collect the requisite materials, but has also supplied me with a few additional varieties of pitchstone; some remarkable for their microscopic structure, others of considerable interest to the petrologist, as they exhibit a transition from the true glassy texture to that of the dull compact "hornstones" and felsites.

Intimately associated with the pitchstones, there frequently occur dykes and other intrusive masses of light-grey rocks of a felsitic or trachytic character; they are all quartziferous, and present several well marked varieties. As these rocks have not been previously described, I purpose giving some account of their structure and mode of occurrence, but will, in the first place, complete my description of the pitchstones.

In my former paper I described the pitchstones on the east and west coasts as occurring in intrusive veins and dykes, and subsequent examination has not only confirmed this view, but has also shown that the sandstones are greatly altered along the line of junction. Prof. Zirkel, on the other hand, states that the vein on the Corriegills shore has not produced the slightest change on the sandstones, and that it is regularly interbedded with them.[2] It became necessary, therefore, to make another careful examination of the locality. The result was, that the sandstone in contact with, or in close proximity to, the pitchstone, is greatly indurated in places, while in others it is comparatively soft; but in these instances there is invariably an escape of water at the junction of the two rocks, and a partial disintegration has been the result; an examination, therefore, of such places only, might easily mislead an observer. As regards the relative positions of the two rocks, I have nothing to add to the previous account; in all the localities examined the pitchstone is clearly intrusive.

In order to insure a tolerably complete investigation of the rocks described in this and the former paper, specimens exhibiting any variations in structure or appearance were taken from each locality; and of these I have prepared forty-one thin sections for microscopic examination.

[1] See Geol. Mag. Vol. VIII. pp. 448–450.

[2] Zeits. d. d. geol. Ges., xxiii., p. 1.

Specimens of pitchstone collected in Monamore Glen and Birk Glen, near the old Lamlash road, afford beautiful varieties of the rock represented in Plate I., Fig 1, combined with the structure of Fig. 2. A dark green pitchstone from Invercloy contains numerous crystals of quartz and felspar, which give it a porphyritic character; the base is a clear colourless glass, thickly crowded with very short, straight belonites, which wind in streams round the larger crystals, but there is no arrangement in groups. Some of the quartz crystals contain remarkable cavities inclosing small fern-like groups of belonites, although there are none whatever in the surrounding matrix.

A specimen of black pitchstone deserves special mention. It was taken from a boulder on the high ground near West Benan; two other boulders of the magnificent porphyritic pitchstone previously described, together with many others of the coarse-grained granite, were lying near it; the whole assemblage being evidently derived from the Goatfell granitic range.

It may be well to observe here, that of the hundreds of boulders scattered over this part of the country, I did not see one of any rock foreign to the island. The specimen in question is quite black, of irregular brittle fracture, and contains a few crystals of felspar and brown augite. The microscopic structure is highly remarkable, and differs considerably from any previously described. With a low power, the colourless glassy base appears to be crowded with numerous groups of slender black prisms, exhibiting the following singular arrangement. A long acicular prism forms an axis, to which are attached, on opposite sides, two rows of similar shorter prisms, projecting from it at right angles, like the teeth of a double comb. With a higher power, the prisms are easily recognized as the usual pyroxenic belonites thickly studded with extremely minute grains of magnetite; the rock itself is rather strongly magnetic. Well formed crystals of orthoclase and plagioclase are imbedded in the base, together with many distinct characteristic crystals of augite. Quartz appears to be absent from this rock.

One of the porphyritic pitchstone boulders just referred to is also of great interest, as it contains a considerable proportion of fine-grained basalt included in it. Under the microscope, the pitchstone itself is seen to be quite the same as that previously described (p. 7), but it contains, in addition, small isolated fragments of basalt, while the basaltic part of the rock incloses quartz crystals, which have included in their cavities portions of the basaltic matrix in which they are imbedded. The basalt is very fine-grained, and consists almost entirely of small, clear, felspar crystals, and very minute grains of magnetite. A few small grains of augite may also be detected.

It has already been explained that the characteristic base of pitchstone is a *homogeneous glass without a trace of double refraction,* and therefore remaining dark between crossed Nicols; the base of felsites, porphyrites, and other allied rocks, is, on the other hand, characterized by a *felsitic* structure, and a felsitic base *invariably* *exhibits double refraction.* In ordinary light, there are seldom any distinct indications of individual forms, the appearance being rather that of a confused imperfectly blended mass of glassy materials. Its true character is, however, well seen in polarized light; the axes of the Nicols being parallel, there are still comparatively few sharp outlines, but as either of the prisms is rotated, the mass appears to break up into variously coloured little patches, which gradually assume a more definite form as the axes approach to a right angle; in that position it has the appearance of a granular compound of crystalline fragments, among which there may be seen, in most cases, a few more or less perfectly formed crystals. It is not, however, a granular compound in the proper meaning of the term: it is evidently a mass which has been consolidated whilst in an incipient stage of crystallization; or, in other words, an originally homogeneous mass has undergone a certain amount of molecular change, insufficient for the development of crystalline forms, but sufficient for the production of double refraction.

It would appear from these facts, that in the case of pitchstone, the conditions under which the consolidation of the matrix took place were altogether unfavourable to crystallization; but that in the case of a felsitic base, the process of crystallization had commenced, and had been arrested, possibly by the act of consolidation. But it is by no means obvious in what way the conditions differed, for it is quite certain, that in both cases, felspar and quartz crystallized out from the mass, and in doing so caught up portions of the surrounding glassy or felsitic matrix. The explanation may however lie in the fact, that there is more silica in the felsitic than in the vitreous parts of these rocks. Concurrently with an incipient crystallization there has also been a partial formation of distinct constituents; for in most cases, if not in all, quartz may be distinctly recognized. Although the peculiar texture just described may be regarded as the chief characteristic of a large class of rocks, it is only in typical specimens that it exclusively prevails, for it will be seen, that by a gradual increase in the quantity of granular and crystalline particles, it passes into a more or less perfectly crystallized structure. It will shortly be shown that felsitic substances frequently occur in pitchstone, and in the following descriptions the term will always be used to indicate the structure just explained.

On the west coast, between Drumadoon Point and the headland called Cleitadh nan Sgarbh, the cliffs round the bay consist of red sandstones traversed in places by veins of pitchstone and red jaspery "hornstone." One of them near King's Cove is a brown pitchstone, forming a vein high up in the cliff, and is a rock of special interest, as it is very variable in structure, and shows clearly that ordinary pitchstone, and the compact red "hornstone," are simply modifications of one and the same mass. Four specimens taken from this vein exhibit the following varieties:—

1. A yellowish-brown pitchstone, full of small round grains and narrow bands, differing slightly in colour from the glassy base.

2. A brown pitchstone, of duller aspect than No. 1, containing spheroidal nodules of light brown compact "hornstone," having a bluish-grey nucleus; the nodules are from 1 to 2 inches in diameter, and contain many crystals and grains of quartz, with some of felspar.

3. A specimen, containing the two former varieties, with a little red "hornstone."

4. A compact red "hornstone," with crystals of quartz and felspar; a portion of one specimen also exhibits a minute spherolitic structure.

Under the microscope a section of No. 1 exhibits, in ordinary light, a pale yellow glass, full of well-defined circular aggregations of a reddish-yellow substance, which appears indistinctly granular; these are the grains seen in the specimen; they will be described as spherolites. Great numbers of short green belonites are scattered through the base, and there are many crystals of quartz, orthoclase and plagioclase, the latter are beautifully striated. A crystal of quartz or felspar sometimes forms the nucleus of a spherolite, numbers of belonites radiate from it, and the group is surrounded by one or more concentric coloured bands; frequently, however, the spherolites have no distinct nucleus. The true character of the rock is better seen in polarized light; between crossed Nicols the glassy base of course remains dark, and on this black ground numerous spherolites and small patches of felsitic matter are very well seen. The spherolites invariably exhibit double refraction, but no felsitic structure; in ordinary light many are quite clear, and the only indication of a radial structure is the direction in which the belonites lie. Between crossed Nicols, however, a black cross is seen, and on rotating either of the prisms the arms of the cross also rotate; this is of course indicative of a minute radial crystallization.

The dull brown pitchstone, No. 2, which contains the nodules, exhibits many spherolites like No. 1, aggregations of felsite, and also characteristic groups of belonites.

The "hornstone" nodules consist of the usual glassy base, nearly filled with a fine brown dust, which renders it dull and semi-opaque; a very thin section exhibits however a somewhat similar structure to No. 2; but the belonites are longer, and there are very few fern-like groups; larger portions of the base are felsitic, quartz crystals are more abundant, and there are several small masses of amorphous quartz.

The grey nucleus of the nodules exhibits a characteristic felsitic texture, together with imbedded crystals of quartz and felspar.

The red "hornstone," No. 4, consists of a very compact felsitic base, with much colouring matter disseminated through it, and it also contains crystallized quartz and felspar.

I am fortunate in being able to give the results of a very careful analysis of two of these rocks by Mr. J. Arthur Phillips, who kindly undertook the examination, and made a double analysis of each. No. I. is the "hornstone" nodule. II., the red felsite or "hornstone." III., a globular felsite, to be presently described; also analyzed by Mr. Phillips:—

	I.		II.		III.	
	1.	2.	1.	2.	1.	2.
Water [1]	8·23	8·14	3·58	3·59	1·47	1·47
Silica	73·90	73·78	78·05	77·92	78·32	78·02
Alumina	10·12	10·08	11·12	11·21	11·39	11·46
Ferric Oxide	trace		trace		—	—
Ferrous Oxide	1·23	1·25	1·08	1·17	1·67	1·61
Manganous Oxide [2]	1·19	1·15	0·15	0·17	—	—
Lime	—	—	0·98	0·88	0·13	0·13
Magnesia	trace		trace		trace	
Potassa	2·42	2·44	trace		0·20	0·20
Soda	2·64	2·66	4·94	4·92	7·62	7·72
	99·73	99·50	99·90	99·86	100·80	100·61

Felsites.—On the east and west coasts of the southern half of the island there are several dykes of a light grey felsite, which cut through the Carboniferous sandstones in precisely the same way as the pitchstones and basalts; and sometimes even form portions of the same dykes. These are the rocks frequently mentioned by Dr. Bryce as claystones; they appear to have been but very imperfectly understood, and as they are far more common than the pitchstones, it is singular that Zirkel should have given no description of them in his account of the Arran rocks.

These felsites vary considerably in appearance, some being distinctly spherolitic, while others can scarcely be distinguished from the so-called quartz porphyries; it will, in fact, shortly appear that they possess an intermediate character between the latter and the pitchstones. Referring to the preceding account of their general microscopic structure, it will be convenient to describe, in the first place, a rock of very different appearance, but of essentially the same structure and composition.

Near the small pitchstone vein on the Corriegills shore, there is an intrusive vein of a very remarkable character.

Globular Felsite.—The rock was described by MacCulloch, and has been frequently mentioned by subsequent writers as globular pitchstone, perlitic pitchstone, claystone, and hornstone. It is not mentioned by Zirkel in the paper previously quoted. Dr. Bryce observes: "Mineralogists have long regarded this curious rock with much interest, and various opinions have been held respecting its true relations, some considering it as allied to claystone, and others to pitchstone."[3] It will soon be evident that a microscopic examination of one or two thin sections is quite sufficient to establish its true character.

It is a hard, tough rock of dull greenish-grey colour, full of

[1] In No. I. 2·37 was lost in water bath.
,, II. 1·32 do. do.
,, III. 0·65 do. do.

[2] The whole of the iron in No. I. was found "to be in the state of ferrous oxide, and that fact is sufficient evidence that the manganese exists as manganous oxide." It is worthy of remark, that the felsitic portion of the rock contains more silica than the pitchstone, a result quite in accordance with that obtained by microscopic examination.

[3] Geol. of Arran, p. 77.

spherical concretions, set in a compact matrix. The spheres have a distinct fibrous radial structure, and are frequently coated with a white film. In a very thin section, in ordinary light, the spheres exhibit a well-defined circle, bounded by a line of minute grains of iron oxide, but the fibrous structure is not so distinct; in fact, it then appears to be simply a radial arrangement of the particles of a fine dust scattered through a dull uniform base; dark greenish aggregations of this substance sometimes form an irregular nucleus, throwing off rays towards the circumference; frequently, however, the centre is free from them, and there is then no appearance of any sort of structure. These green patches also occur in the matrix, and both spheres and matrix appear to be composed of precisely the same substance. Placed between crossed Nicols the appearance is completely changed, and it is at once seen that the matrix has a felsitic structure, and that some of the spheres are also composed of portions of the same substance, which have, however, undergone a process of aggregation and radial arrangement in globular masses; but the felsitic structure is still quite as evident as in the base. Many of the spheres are, however, composed of two or more concentric layers; in some there is a felsitic nucleus surrounded by radiating groups of the green dust; in others the nucleus consists of grains of quartz only. The globular concretions here described differ entirely in structure and appearance from the spherolites occurring in the pitchstones, and it is quite evident that the rock is a felsite. Some specimens may, at first sight, be readily taken for a dull perlitic pitchstone, but a microscopic examination shows very clearly that it is not a pitchstone, and that the structure is not perlitic.

On the shore south of Tormore there is a compound dyke about 20 feet wide, the two sides consist of basalt, while the central part, 12 feet in width, is composed of a hard light grey felsite, containing crystals of quartz and a few of felspar; the latter are chiefly orthoclase, but plagioclase is also present. The base is felsitic, and contains many perfectly clear spherolites with radiating belonites; this is the only indication of structure in ordinary light, but between crossed Nicols there is a well-defined black cross. The larger quartz crystals are surrounded by a continuous clear band, containing tufts of radiating belonites, and between crossed Nicols the tufts are seen to mark the places of imperfectly formed spherolites, more or less complete black crosses being then visible. Many belonites, and small opaque grains, are scattered through the base, and they assume a stream-like arrangement round the sides of the larger crystals.

In Monamore Glen, about a mile above the mill, there is a small quarry worked for road metal. The rock is a hard felsite, varying in colour from greenish-grey to light brown; it contains a little felspar, and numerous crystals of quartz; the latter being surrounded by a green border, give the rock an unusual appearance. The base is felsitic, contains many green belonites, and is quite as distinctly spherolitic as the specimen just described. In addition to many clear spherolites, there are others of a dull green substance, having a radial arrangement, but not distinctly crystallized. The quartz crystals contain many cavities inclosing portions of the base, and are invariably surrounded by a band of green spherolites so closely packed together as to interfere with their full development. The felspar is much altered, but a few crystals still display coloured bands and striæ.

A spherolitic felsite appears to form an intrusive vein on the south slope of Dun Fion above the Corriegills shore. It is a rather hard yellowish-grey rock, full of small spherical grains, without imbedded crystals. Under the microscope, with ordinary light, the felsitic base appears to be full of brown dust, with many imperfect belonites scattered through it; there are also many clear circular spaces, which exhibit no structure whatever. Between crossed Nicols, however, a spherolitic structure is at once evident; the clear spaces then display one or more circular disks traversed by a black cross. This kind of latent, or crypto-spherolitic texture, is the same as that previously described in the pitchstones. There are many small spherolites of distinctly fibrous structure.

We have previously seen that the brown pitchstone from King's Cove passes into a felsite, and in the rocks just described we have examples of typical felsites containing spherolites and belonites, differing in no respect from those common in pitchstones.

On the Lamlash road, about a mile from the Brodick Hotel, there is a mass of spherolitic felsite in connexion with the vein of pitchstone, which is well exposed in the bed of the stream below. It is the bed of "claystone" mentioned by Dr. Bryce, who describes the relative positions of the two rocks, and observes, that "the relations of the two beds lend countenance to the idea that these claystones are but altered sandstones." It is by no means easy to understand how any one who had given some attention to igneous rocks could entertain such an idea. In external appearance the rock is not unlike a nearly white Oolitic limestone, full of small yellowish grains. Under the microscope a thin section shows the grains to be spherolites of fibrous radial texture, thickly scattered through a felsitic base containing many distinct grains of quartz. The rock is somewhat decomposed, but a few of the spherolites still exhibit traces of belonites.

A crystalline felsite from Auchenhew Hill, about a mile and a half N.W. of Kildonan Castle, is an interesting rock, as it exhibits a composition and structure combining the characters of the felsites with those of the more perfectly crystallized dolerites, and may, therefore, be compared with the well-known trachy-dolerites. It is of a light grey colour, distinctly crystalline in texture, and contains a few crystals of orthoclase. The felsitic base contains grains of quartz, and many spherolites, like the preceding rocks; but there are in addition numerous small felspar crystals, and long prisms of a brown pyroxenic mineral, too much altered for determination: it is probably altered hornblende. There are also many black grains of magnetite; the larger felspar crystals are twins of orthoclase. This rock occurs high up among the sandstones on the south side of the hill; the latter being capped by a thick sheet of columnar dolerite.

The felsites just described all form dykes or veins in the sandstones; but there is a rock, of similar appearance, which occupies a considerable area in the vicinity of Lagg. It nowhere reaches the coast, but is first seen a few hundred yards south of Clauchog farm, and extends in a northerly direction for at least two miles; and from Sliddery Water, on the west, to the Cloined burn, near the well-known shell-bed, on the east, a distance of a mile and a half; how much further it may extend in both directions is uncertain, as I had no opportunity of tracing it. In Sliddery Water it is first seen in the bed of the river, about 700 yards above the bridge, where there is a fine junction with the sandstones. The side of the felsite is vertical, with the ends of the sandstone strata abutting against it, and dipping away at an angle of 30°; the felsite here crosses the river, and occupies both banks as far as Glenrie Mill. It appears to be continuous within the limits observed, and in the Cloined burn the relations of the two rocks are the same as in Sliddery Water. In this instance a mass has probably flowed over the sandstone, and has been brought into its present position by faults.

The rock is very uniform in character, generally of a light-grey colour, but often marked with reddish-brown bands and concentric rings. The base is finely granular, and contains many small crystals of felspar and quartz, with numerous grains of magnetite. Under the microscope the base appears distinctly granular, and contains much quartz; orthoclase and plagioclase are both present, though much altered; the quartz is well crystallized, sometimes exhibiting short prisms doubly terminated.

Porphyritic Felsites, or quartz porphyries, as they have generally been called, occur in many places in Arran, frequently as dykes in the Carboniferous sandstone, or forming extensive overlying masses. The best localities on the west coast are Drumadoon Point, Leac a breac between Blackwater foot and Sliddery Water, and Benan Head; and on the east coast, Dun Dhu between Brodick and Lamlash. As Zirkel has given an account of these rocks in the paper cited above, a brief description of two varieties will now suffice. Benan Head is formed entirely of a mass of various intrusive rocks, of which a beautiful "quartz porphyry" forms the greater part. It is a pale-grey rock, containing numerous large crystals of orthoclase and quartz in a compact base; the orthoclase is clear and glassy, like sanidine; the quartz is well crystallized in short prisms doubly terminated.

Under the microscope, in polarized light, the base exhibits a perfectly characteristic felsitic structure, with a very few imperfectly formed felspar crystals, and a little quartz; there are also many small black grains of magnetite. Nearly all the felspar is orthoclase, but Zirkel's statement that there is no trace of plagioclase requires to be modified, as one of my sections contains a crystal which exhibits well-defined coloured striæ. The larger crystals of quartz and felspar contain many cavities, with included portions of the base.

The columnar "porphyry" at Drumadoon Point is of a darker colour than the preceding rock, and some of the orthoclase crystals are quite opaque; others are glassy in the middle, with an opaque coating. The dark colour is due to the presence of a great number of grains of magnetite and a little chloritic mineral scattered through the base; there are also a few crystals of a pyroxenic mineral altered to the same green substance. The base exhibits a more crystallized structure than the rock from Benan Head, and in this respect resembles the felsite from Auchenhew Hill previously described.

It should be distinctly understood that in calling these rocks felsites or quartz porphyries, nothing is implied thereby as to their age; they might with equal propriety be called trachytes, and would certainly be placed in the trachytic group, if they were known to be of Tertiary age; there is no mineralogical or structural difference between them and the recent trachytes, nor on the other hand is there anything to distinguish them from much older rocks. If any petrologist thinks he can determine the age of such rocks by their chemical or mineralogical composition, he might try his skill on these Arran felsites before their age is ascertained by other means. So far as is yet known with certainty, they may have been intruded at any time between the close of the Carboniferous and the close of the Tertiary Periods; there is here, therefore, an excellent opportunity of solving a difficult problem, and any one who has discovered a criterion for determining the age of eruptive rocks would render great service to science by making it known. Although there is at present great confusion in petrological nomenclature, a partial alteration, or introduction of new terms, would only make matters worse; and as more exact methods of observation are now being employed, it will not be very long before the composition and structure of most rocks will be known. Petrologists will then be able, for the first time, to adopt a nomenclature founded on a knowledge of facts; for it should be remembered that most of the names by which the fine-grained rocks are known were given in complete ignorance of their true composition. In the meanwhile no harm can be done by discontinuing the use of a number of terms which have lost, or never had, any definite meaning; for example, the names 'porphyry' and 'porphyrite' may be dismissed as quite unfit for generic terms, the structure to which they are applied being frequently found in all kinds of igneous rocks, and therefore characteristic of none. It should be restricted to its proper use as a varietal character only, and such names as 'felspar-porphyry,' 'pitchstone-porphyry,' etc., should give way to 'porphyritic felsite,' 'porphyritic pitchstone,' etc. Another step would be to ignore the distinction now made between rocks of different ages, when there is really no essential difference between them; we should then get rid of *melaphyr*, *aphanite*, *anamesite*, *diabase*, and *greenstone*. The three former are but varieties of 'dolerite,' 'diabase' is simply an altered 'dolerite,' while 'greenstone' has now no definite meaning whatever, having been applied to diorites, dolerites, felsites, or in fact to any rock which a collector or writer could not make out. An indefinite term is of course frequently useful in the field, and perhaps none could be better for the purpose than *trap*.

I would observe, in conclusion, that, although much has been written on the geology of Arran, comparatively little is accurately known, especially as regards the rocks in the southern half of the island. A few rambles along the shore and among the hills should surely teach a geologist that there are igneous rocks of different ages, presenting various modes of occurrence; yet such important distinctions as those between interbedded sheets and intrusive dykes have been generally overlooked or completely misunderstood. What is now wanted is a good geological map and memoir, a work which could not be in better hands than in those of Prof. Geikie and his staff, and with which it is to be hoped geologists may soon be favoured.

V.—On the Temperature and other Physical Conditions of Inland Seas, in their Relation to Geological Inquiry.[1]

By William B. Carpenter, M.D., LL.D., F.R.S., F.G.S.

The researches in which the Author has been personally engaged during the last four years into the Temperature and other Physical conditions of the Deep Sea, combined with the information he has obtained from other sources, have led him to the knowledge of certain remarkable differences in regard to these conditions, which prevail between Inland Seas and the open Ocean. As these differences have a most direct and important bearing upon the distribution of Animal life, and as it would seem highly probable that similar differences have existed in all Geological periods, he thinks it important that Geologists, by being made aware of them, should be in possession of a key that seems likely to open the way to a rational interpretation of many Palæontological phenomena which are at present obscure.

The *general facts* in regard to Ocean Temperature, which have been determined by recent observations, are briefly as follows:—

1. In high Northern latitudes, the Temperature of the *surface* of the sea, near the border of the ice barrier, is but little above 32°; and at small depths below the surface, according to the recent observations of Payer and Weyprecht, it falls below 32°. Making allowance for the known influence of pressure upon the thermometers with which temperature-observations at great depths have been made in these regions, there is every reason to believe that—save in cases in which the temperature of the upper stratum may be modified by local causes—there is a progressive descent from 32° to 29°, or even lower; so that the average temperature of the *entire column of Polar water* may be considered to be not above 30°.

2. In lower latitudes, the Temperature of the surface of the sea is greatly influenced by solar radiation; but the *superheating* thus produced does not generally extend in a marked degree much below 100 fathoms. Beneath this, in the Atlantic, is a stratum of which the temperature may be said to range from about 52° to 45°, in all but the highest latitudes; but the depth of this stratum varies considerably, extending downwards to about 500 fathoms near the Faroe Banks, to about 700 fathoms off the coast of Portugal, and to 1,000 or 1,200 fathoms nearer the Equator.

3. Beneath this stratum is a "stratum of intermixture" in which the thermometer falls rapidly, sometimes as much as 10° in 200 fathoms; and below this the temperature again becomes more uniform, sinking very gradually from 39° or 38°, to 36° or 35°, at depths of 2,000 fathoms or more, near the Eastern border of the North Atlantic. It is probable that Temperatures yet lower than these will be found to prevail over the deep bottom of the Mid-Atlantic; the recent Temperature-soundings of Captain Chimmo in the Eastern Seas, made with 'protected' Thermometers, having now fully demonstrated that, *even under the Equator*, the bottom-temperature at great depths of the Ocean may be as low as 32°.

4. Thus the Intertropical column may be considered as consisting of (1) a *superheated stratum*, of which the temperature ranges from 84° at the surface to 52° at

[1] Extracted from *The English Mechanic and World of Science*, for September 20-27, 1872, with additions and corrections by the Author.

200 fathoms; (2) an *upper warm stratum* of (say) 1,000 fathoms' depth, of which the temperature ranges from 52° to 45°; (3) a *stratum of intermixture* of about 200 fathoms' depth, in which the thermometer falls from 45° to 39°; and (4) of a *cold stratum* occupying the whole of the deeper portion of the great Oceanic basins beneath 1,400 fathoms, its temperature falling with increase of depth, so that in its deepest portion the thermometer has been seen as low as 32°. The *average* of the entire column may thus be about 45°.

Now, as *Sea* water progressively diminishes in bulk and increases in Specific Gravity down to its freezing point, it is maintained by the Author that supposing the Polar and Intertropical columns to be equal in height, the excess of weight in the former will produce a lateral pressure at its lower portion, which will occasion an outflow of Polar water along the floor of the ocean, towards the Equator; this deep outflow, by lowering the surface, will produce an indraught of water into the Polar area, which, in its turn, will acquire by cooling the same excess of Specific Gravity, thus producing a continual *downward* movement; while on the other hand the deep outflow, being subject to the heating influence of the crust of the earth beneath, and of the warmer water above, will be gradually thinned as it passes towards the Equator, so as to lie at a greater and greater depth beneath the surface. As the continual indraught into the Polar area must ultimately be supplied from the surface of the Intertropical sea, there will be a continual movement of the *upper* stratum *from* the Intertropical towards the Polar area; while as the last-arrived Polar water will always be colder than that which preceded it, the former will take its place beneath the latter, so that there will be a continual *upward* movement of the water in the Intertropical area.—Of this upward movement of colder water from below, a very curious indication has lately been obtained in the fact that off the west coast of Africa the temperature of the sea at 200 fathoms is about 5° lower over a bottom deep enough to be covered by the Polar overflow, than it is over a bottom of only 700 or 800 fathoms' depth.

The doctrine of a *vertical circulation* advocated by the Author was long since suggested by Pouillet as the best explanation of the facts then known in regard to Ocean-temperature; but it was put aside through the general acceptance of the doctrine of a uniform deep-sea temperature of 39½°, which was supposed to have been established by Sir James Ross's observations, and which was adopted and promulgated by Sir John Herschel. The corrections supplied by more recent and trustworthy observations have afforded a new set of data; on the basis of which it has been argued by the Author, that such a Circulation *must* necessarily take place under the conditions above specified, and that it gives an adequate scientific *rationale* for the facts determined by observation. And his views on this subject have been accepted by Sir John Herschel and Sir William Thomson.

Now, it is obvious that if this doctrine of a Vertical Oceanic Circulation, sustained by antagonism of Temperature, be admitted, the thermal condition of any Inland Sea that is cut off from any but a superficial communication with the great Oceanic basins, and at the same time corresponds with them in depth, must be very different. Of such a sea, the Mediterranean is a typical example. It consists of two very deep basins: the Western, which extends from the Strait of Gibraltar to the Adventure and Skerki Banks that connect Sicily with the coast of Tunis, having a depth which ranges, over a large part of its area, to 1,000—1,600 fathoms; whilst the Eastern, which extends from Malta and the eastern coast of Sicily to the Levant, is yet deeper, its bottom having in some parts a depth of nearly 2,000 fathoms. The Strait of Gibraltar, which constitutes the sole channel of communication between the Mediterranean basin and the outside Atlantic, and which has a depth of about 500 fathoms between Gibraltar and Ceuta, gradually shallows, as it widens, towards its western *embouchure* between Capes Trafalgar and Spartel; where there is a "ridge," or "submarine watershed," of which the average depth is about 120 fathoms, certain passages across it approaching 200 fathoms in depth. Through this Strait there is a double current, modified in force and direction by Tidal action, as the researches which the Author carried on last August in conjunction with Captain Nares have shown: the *predominant* movement of the *upper* stratum being *inwards*, while that of the *lower* stratum is *outwards;* and the quantity of water which thus *enters* the Mediterranean from the Atlantic being considerably greater than that which *flows out* of the Mediterranean into the Atlantic. The surplus of the upper current goes, as was maintained nearly 200 years ago by Dr. Halley, to make up for the loss sustained by the water of the Mediterranean, in consequence of the excess of evaporation from its surface over the whole quantity restored to it by rain and rivers; whilst the outward under-current serves, by continually carrying back a portion of the denser Mediterranean water, to prevent the accumulation of salt in the Mediterranean basin, which would otherwise result from the continual inflow of *sea* water in place of the *fresh* water that has passed off by evaporation. This outflow the author believes (with Captain Maury) to depend upon the excess of weight of the Mediterranean column above the Atlantic column; its immediate physical cause, therefore, being exactly the same as that of the outflow of bottom-water from the Polar area.[1]

It will be obvious from what has preceded, that the Gibraltar in-current will produce very little change in the *temperature* of the Mediterranean; since, as its depth on the "ridge" is little more than 100 fathoms, the water which it brings-in will entirely belong to that superficial stratum whose temperature depends upon solar radiation. The *summer* temperature of that stratum in the Atlantic is a few degrees *below* that of the superficial stratum of the Mediterranean; and the *winter* temperatures of the two are about the same. We may, therefore, throw the thermal influence of the Gibraltar in-current out of consideration, except as regards its influence in slightly lowering the *surface*-temperature of the westernmost portion of the Mediterranean. The temperature of the *deeper* stratum will never be affected by it, since it is always below that of the water entering by the Strait, which will float upon it in virtue alike of its lower salinity and of its higher temperature.

The Summer temperature of the *surface* of the Mediterranean, where not depressed by the entrance of Atlantic water, generally ranges between 70° and 80°. But this temperature rapidly falls in passing from the surface downwards; as much as 20° being sometimes lost in the first 30 fathoms. In the Western basin, the thermometer generally sinks at 50 fathoms to 55° or 56°; and below this we observe very little change down to 100 fathoms, at which it usually stands at 54°. From this to the bottom, however deep that bottom may be, the temperature continues *uniform*, the water between 100 and 1,600 fathoms having absolutely the same temperature of 54° throughout. In the Eastern basin, of which the axis lies about 2° further to the south, the heat of the superficial stratum extends somewhat further down; but the uniform temperature is always reached at less than 200 fathoms; and from that depth to the bottom at (it may be) 2,000 fathoms, the temperature of 56° degrees is found everywhere to prevail.

Now, it is obvious from these facts (1) that Depth *per se* has no effect in reducing temperature; (2) that the uniform temperature of the Mediterranean from 100 or 200 fathoms to the bottom must be determined by some *local* condition; whilst (3) as this condition might be expected to have the same effect on the water of the outside Atlantic under the same parallel of latitude, the coldness of *its* lower stratum, ranging, from 900 fathoms downwards, between 39° and 36·5°, must be due to the importation of water from a Polar source. What, then, is the determining condition of the uniform temperature of 54° in the Western basin of the Mediterranean, and of 56° in the Eastern?

In the Report (for 1870) of his first researches in the Mediterranean, the Author attributed it to the *sub*jacent influence of the warm crust of the earth, the temperature of which in the Mediterranean area, as indicated by the uniform temperature of a deep cave in the Island of Pantellaria, and by that of the deepest tanks in Malta, seems to be 54°. But he is now inclined to believe that this coincidence is accidental only, and that, no colder water being admitted from without, the uniform temperature of the mass of Mediterranean water in each basin really corresponds to its *lowest winter mean*, or *isocheimal* temperature. According to the best information he has been able to obtain, the Winter temperature of the Western basin is 54° from the surface to the bottom, while that of the Eastern basin is 56° throughout; the slight excess in the latter being due to the small difference in latitude, with the effect of the hot winds from Central Africa. As the sun gains power, its radiation raises the temperature of the superficial stratum, but does not penetrate far downwards; and thus the great mass of the water beneath remains unaffected by it. If, on the other hand, the Winter temperature of the surface were to be reduced, that reduction would affect the entire mass; because, as the surface-water is cooled, it sinks, and diffuses its cold through the water beneath.

Thus the bottom-temperature of a deep Inland Sea may be expected to depend

[1] So in the case of the Black Sea, it was maintained by the Author that the excess of Specific Gravity of the Ægean water must produce an inward under-current through the Dardanelles and the Bosphorus; and this prediction, which was affirmed by Captain Spratt to have been disproved by his own previous researches, has recently been verified by the "Shearwater" investigations.

upon one or the other of two conditions; *first*, the mean Winter temperature or *isocheimal* of the surface; and *second*, the temperature of the coldest water that is admitted into it from the Ocean outside. If its communication with that ocean be so shallow that the temperature of the water admitted through it is never lower than the *isocheimal*, then the latter will be the uniform temperature of the entire mass beneath the variable surface-stratum; but if the communication be deep enough to admit the water of a colder stratum of the Ocean, the bottom-temperature of the Inland Sea will be the temperature of this stratum.

Let us see how this view applies to two other cases. The Red Sea, like the Mediterranean, is almost entirely cut off from communication with the deeper and colder stratum of the Arabian Gulf, with which its surface-layer communicates through the shallow Strait of Babelmandeb; for whilst the lowest temperature observed in that surface-layer, even in the northernmost extension of the Red Sea known as the Gulf of Suez, is 71° (as I learn from Captain Nares, who has been recently engaged in its survey), that temperature is there uniformly carried down to the bottom at 450 fathoms; and it may hence be pretty certainly affirmed that no lower temperature than this will be found in the southern portion of the Red Sea, even on a bottom exceeding 1000 fathoms in depth, since the *lowest* surface-temperature of that portion is probably never less than 75°, the *highest* being nearly 90°. Yet, in the Arabian Gulf, the temperature at a depth of 2,000 fathoms is certainly not *above*, and is very probably *below*, 36½°. Here, therefore, the uniform temperature which will probably be found to prevail throughout, beneath the surface-stratum, will be the *isocheimal*.

Now it seems to be the universal opinion of those who have most carefully studied the existing Coral Formations, that the reef-building corals do not live and grow at a greater depth than 20 fathoms; and since it is affirmed by Mr. Dana as a deduction from the distribution of coral formations, that the existence of the reef-builders is geographically limited by the isocheimal line of 68°,[1] the Author cannot but suspect that the *bathymetrical* limit may be essentially a *thermal* one.[2] For all we know of the relation of Temperature to Depth would indicate that even within the Intertropical area of the open Ocean, the temperature at 20 fathoms may not be above 68°, and that in the next 10 fathoms it suffers considerable reduction. Now if the temperature of the Red Sea nowhere falls below 71°, it is obviously a most interesting question to determine whether the reef-building Corals are or are not to be found in that sea at a greater depth than in the Oceanic area; and if so, what is the greatest depth at which they exist there. For since the Author's previous inquiries have shown that Stony Corals, similar in all essential particulars to the reef-building types, can live and grow at the depth of many hundred fathoms, there seems no *à priori* reason why the latter should not thrive at like depths, if the Temperature be congenial to them.

A similar contrast is shown by the Temperature-soundings of Commander Chimmo (which have been kindly communicated to the Author by the Hydrographer) between the deep temperature of the Sulu Sea, a small area between the north-eastern portion of Borneo and Mindinao, and that of the China Sea. The former, though not ostensibly an Inland Sea (being but very partially surrounded by land), is so shut in by reefs and shoals, as to have only a very superficial and limited communication either with the China Sea or with the Celebes Sea. Notwithstanding this inclosure, its depth is very great, ranging to 1,603 fathoms; and its Temperature-phenomena present *exactly the same contrast* with those of the China Sea,[3] that the Temperature-

[1] "On Corals and Coral Formations," p. 108.

[2] It is a very significant fact that the cold current which comes up from the south on the eastern coast of South America, and which the Author regards as the indraught of the Pacific Equatorial current (as the similar current on the eastern coast of South Africa is of the Atlantic Equatorial current), pushes the southern isocheimal of 68°, the Coral Sea boundary, to the north of the Equator, between the South American coast and the Galapagos, which, though under the Equator, lie outside of that boundary.

[3] The Temperatures here given are those of the *bottom* at different depths in the line of the telegraph cable between Singapore and Hong-Kong. Why the fall of temperature from 51° to 37° should seem to take place in the China Sea at so much smaller a depth than it does in the Atlantic, cannot be positively affirmed until we have *serial* soundings which shall give the Temperatures of successive strata in the deepest part of that sea. But as the temperatures given above are those of the *bottom* at various depths, *on the sides of a valley*, and as the careful researches of the United States Coast Survey have placed it beyond all doubt that the colder

phenomena of the Mediterranean present when compared with those of the Eastern Atlantic, as will be seen in the following table:—

Sulu Sea.			China Sea.
deg.			deg.
83	... ...	surface	 84
—	... ...	30 fathoms	 77
—	... ...	40 ,,	 74
—	... ...	50–80 ,,	 71
64·5	... ...	100 ,,	... ... —
—	... ...	120 ,,	 62
—	... ...	150 ,,	 56
—	... ...	200 ,,	 51
—	... ...	250 ,,	 49
51·5	... ...	308 ,,	... ... —
—	... ...	416 ,,	 41
50	... ...	500–1603	... ... —
—	... ...	673–1546	 37

Thus it appears that with a Surface-temperature almost exactly identical, and with a rate of descent through the Sub-surface stratum which seems nearly the same, there is a most marked difference beneath. For whilst, in the Sulu Sea, the thermometer only falls from 51½° at 308 fathoms to 50° at 500 fathoms, and the temperature is uniform from that point down to the bottom at 1,603 fathoms, the thermometer undergoes a rapid descent in the China Sea from 49° at 250 fathoms to 41° at 416 fathoms, and thence to 37° at 673 fathoms, at which point it remains stationary down to the bottom at 1,546 fathoms. This difference is attributed by Capt. Chimmo, in the Author's opinion with adequate reason, to the exclusion from the Sulu Sea of the deep Polar (Antarctic) current, which lowers the temperature of the China Sea. That the uniform temperature of its deep water from 500 fathoms downwards is *lower* by 4° or 5° than that of the Mediterranean, notwithstanding that it is so much nearer the Equator that the temperature of its superficial stratum is considerably higher, can be easily accounted-for on the very probable supposition that there are passages between its bounding reefs and islands, which admit water of a temperature below 50° from the outside sea. In fact, we might fix the probable depth of such passages at about 250 fathoms.

The influence of a still less complete seclusion from the Polar under-flow is shown in the Celebez Sea, which has lately been found by Capt. Chimmo to have the extraordinary depth of 2667 fathoms, with a bottom-temperature of 38½°; whilst at nearly the same depth in the Indian Ocean a little to the west of Sumatra, the bottom-temperature was 32°. And the land-locked condition of the Gulf of Mexico seems to furnish the explanation of that extension of a high temperature to a much greater depth than in ordinary Atlantic water, which is the distinguishing attribute of the Gulf Stream; as the Author has shown in his Report of the 'Shearwater' Scientific Researches (Proceedings of the Royal Society, vol. xx. pp. 615–619).

In his Report for 1870,[1] in which year the Author's researches were confined to the Western basin of the Mediterranean, he described the fine muddy deposit which is being formed over the whole of its deeper portion; this probably consists mainly of the minuter particles brought down by the Rhone, which appear to be diffused through the entire mass of the water of the basin, and to be gravitating very slowly to the bottom—the lowest stratum of water being everywhere rendered turbid by their accumulation. Last year he found the same condition to prevail over the bottom of the Eastern basin, the sediment having been there obviously brought down, for the most part, by the Nile. This turbidity of the bottom-water appeared to him to afford a rational explanation of the *extreme scantiness of animal life* on the deep bottom of the Mediterranean,[2] which presented a most unexpected contrast to its abundance, even at temperatures more than 20° lower, on the deep bottom of the

and heavier stratum underlying the Gulf Stream comes nearer the surface with every rise of the bottom over which it flows, I think it may fairly be presumed that the same cause is in operation here also; as it seems to be likewise in the "Lightning Channel" between the north of Scotland and the Faroe Islands.

[1] Proceedings of the Royal Society, vol. xix. pp. 199-202.

[2] His results on this point have been confirmed by the results of Oscar Schmidt's dredgings in the Adriatic.

Atlantic. In fact the almost *azoic* condition of the abyssal depths of the Mediterranean, whilst its shallower portions teem with life, shows that Edward Forbes's doctrine (based on his researches in the Ægean) as to the limitation of animal life to a depth of 300 fathoms, seems to be generally true of the Mediterranean, although quite inapplicable to Oceanic basins.

Whilst not abandoning the belief that the Turbidity of the bottom-water unfavourably affects its suitableness as a residence for most marine animals, the Author is now disposed to attribute more influence to the other condition which he suggested in his Report for 1870 (p. 203), as likely to operate prejudicially to Animal life—namely, *the stagnation produced by the almost entire absence of vertical circulation.* In the great Oceanic system, if the doctrine previously advocated be correct, every drop of water is, in its turn, brought to the surface, and exposed to the purifying influence of prolonged exposure to Atmospheric air; whereby a large proportion of its Carbonic Acid and other products of the decomposition of Organic matter will be removed, and Oxygen will be absorbed in their place. But from this movement the water of the Mediterranean may be said to be virtually excluded. Now, as the Nile and the Rhone, to say nothing of other rivers, are constantly bringing down a very large quantity of Organic matter, the finer particles of which seem to be diffused through the whole mass of the water in the two basins, and to be slowly gravitating to their bottom, it might be anticipated that in their gradual decomposition they would generate Carbonic Acid at the expense of the Oxygen dissolved in the water; so that the abyssal water, being separated from the atmosphere by an intervening stratum of many hundred fathoms, and being never brought up to the surface, would come to be unfit for the maintenance of animal life.

Now in the *Porcupine* Expedition of 1869 it was found that the presence of a very large proportion of Carbonic acid in the bottom-water of the Ocean was not incompatible with the existence of Animal Life in great abundance. In fact, there was reason to believe that there was a general relation of conformity between the proportion of Carbonic acid and the amount of Animal life on the bottom as indicated by the dredge-results; the effect of the respiratory and other changes produced by the latter being to increase the proportion of carbonic acid at the expense of the oxygen. Thus, whilst the per-centage of Oxygen in surface-water averaged about 25 per cent., and that of Carbonic Acid averaged something less than 21 per cent., the Oxygen in bottom-water did not average above 19·5 per cent., while the Carbonic acid had increased to nearly 28, the per-centage of Nitrogen being reduced, at the same time, from 54 to 52·5. The per-centage of Carbonic acid in bottom-water often rose much higher than this, being frequently between 30 and 40, and in one instance more than 48; but the per-centage of Oxygen did not show a corresponding reduction, being never less than 16, while that of Nitrogen came down from 54 to 34·5. Thus it appeared that *so long as Oxygen was present in sufficient proportion*, the increase of Carbonic acid to nearly half the total amount of gases removable by boiling, did not exert any unfavourable influence on Animal life; from which it might be surmised that the Carbonic acid dissolved in water under great pressure is in a condition altogether different from that of *gaseous* Carbonic acid, as regards its relation to Animal respiration.[1]

In the Author's second visit to the Mediterranean, in the summer of 1871, each of the samples of bottom-water taken in two deep Mediterranean soundings was boiled until no more gas came over; and the total quantity given off, which corresponded very closely with the average obtained in former Expeditions, was divided in each case into two parts, so that there were four specimens in all. The composition of these specimens agreed very closely, the per-centages being approximately (for the Author does not pretend to minute accuracy) as follows:—Oxygen, 5; Nitrogen, 35; and Carbonic acid, 60. Thus it appeared that very nearly the whole available Oxygen had been converted into Carbonic acid, so that while the proportion of Oxygen to Carbonic acid was never, in the open sea, less than *one-third*, it was here no more than *one-twelfth*,—a difference fully adequate to account for the paucity of Animal life on the deep bottom of the Mediterranean.

That this condition does not extend to those moderate depths in which the water is subjected to the disturbing action of winds, tides, and currents, may be fairly presumed; but whether it prevails through the whole stratum beneath 250 or 300

[1] It is by no means improbable that such sluggish animals as Mollusks and Echinoderms may be able to bear a much larger proportion of Carbonic acid in the water they breathe, than Fishes and Crustacea. Experimental inquiries upon this point, which might be readily carried out in connexion with any large Aquarium, would give results of great Physiological interest.

fathoms, so as to constitute the essential condition by which Animal life is limited to these depths, it would obviously be premature to assert. The Author ventures to think, however, that he has shown that the Physical conditions of any Inland sea, which, like the Mediterranean, is cut off from the general Oceanic circulation, must be such as greatly to modify its relation to Animal life; and that it is a matter of great scientific importance, especially in relation to Geological inquiry, that these conditions should be carefully inquired into.

The Red Sea would probably be found to present in many particulars a striking contrast both to the Mediterranean and to the open Ocean. Its Thermal condition, as has been already shown, is altogether peculiar; for while its surface-temperature rises as high as that of any Intertropical portion of the Ocean, that temperature seems to be maintained with very little reduction, even to its greatest depths. But the Red Sea further differs essentially from the Mediterranean, in not being the recipient of any great Rivers bringing down *detritus* from the land. This, of course, will affect the condition of the bottom, on which we should not expect to find the abundant sedimentary deposit that is everywhere settling down in the abyssal depths of the Mediterranean. It will also leave the bottom-water clear: and in this respect the condition of the bed of the Red Sea will be more favourable to Animal life than that of the Mediterranean. But the absence of Organic sediment, if the views previously adduced be correct, will constitute a still more important difference between the conditions of the two seas in relation to Animal life; for while its progressive decomposition in the abyssal water of the Mediterranean consumes its Oxygen and imparts to it Carbonic acid, at a greater rate than "diffusion" can counterbalance without any vertical circulation in the water itself, and thus tends to render the depths of that sea uninhabitable, the absence of the like source of impurity in the water of the Red Sea may be expected to leave its abyssal water in a condition fit to support a moderate amount of Animal life: since the process of diffusion, even without vertical circulation, will maintain a certain amount of interchange of gases between the superficial and the deep strata.

These views are suggested merely as fair inferences from our present very limited knowledge, to be confirmed or set aside by the result of future inquiries.

NOTICES OF MEMOIRS.

Geological Survey of England.

I.—Explanation of Quarter-sheet 98 S.E.; Illustrating the Geology of the Neighbourhood of Kirkby Lonsdale and Kendal. By W. T. Aveline, F.G.S.; T. McK. Hughes, M.A., F.G.S.; and R. H. Tiddeman, B.A., F.G.S.

THIS is a description of part of the Lake District, the greatest portion of the area being in Westmoreland, the remaining parts being in Lancashire and the West Riding of Yorkshire. The rocks described include the Lower Silurian, Coniston Limestone=Caradoc or Bala Beds; Upper Silurian, Coniston Flags and Grits, Bannisdale Slates, and Kirkby Moor Flags=Wenlock and Ludlow Rocks; the Upper Old Red Conglomerate, the Carboniferous series, and the Permian beds. The physical geography of the area is described, and Mr. Hughes points out that all the great valleys in the neighbourhood of Kirkby Lonsdale coincide with lines of fault: these he describes in some detail; he makes a few remarks also on the formation of swallow-holes. The Silurian rocks and their fossils are described by Messrs. Aveline and Hughes, chiefly by the latter. Mr. Hughes gives the account of the Old Red Conglomerate, which is regarded as the basement bed of the Carboniferous series. The Carboniferous rocks are described by Messrs. Aveline, Hughes, and Tiddeman, and the Permian rocks by Mr. Hughes.

Two plates of horizontal sections are given, which are described by Mr. Hughes. Mr. Aveline gives a brief notice of the Alluvium; a detailed description of which is reserved for another memoir, explanatory of the Drift deposits of the area.

This little work contains a great deal of information condensed into a small compass, and at the same time it is furnished in a very readable style.

II.—Report of the Miners' Association of Cornwall and Devonshire. 8vo. (Falmouth, 1872.)

THIS Report contains, among other matters, some observations by Mr. Wm. Argall on "Gossans." He defined "gossan" as a mixture of cellular quartz and earthy oxide of iron, often found in the upper parts or "backs" of mineral lodes. He also stated that oxide of tin was, in Cornwall at least, a very common ingredient in gossan. It results from the partial decomposition of the upper part of the lode, and is generally valuable as an indication of metalliferous deposits. Gossan is particularly characteristic of copper lodes. The backs of tin lodes do not usually show so much gossan as those of copper or iron lodes, although in some instances gossan has been seen at depths of thirty fathoms. In lead lodes, associated with pyrites, it often happens that before the lead ore is reached, the miners come upon a variety of green and brown gossans of different mineral and chemical characters.

Captain Maynard read a paper on "Heaves" and "Slides"; Captain Noble made some remarks on lodes of iron ore in the parish of Constantine; and Mr. H. Stephens described the mineral phenomena of Huel Rose in the parish of Sithney.

III.—Post-Glacial Geology of Lancashire and Cheshire.

IN the Geological Magazine for March we published a paper by Mr. T. M. Reade on the Post-Glacial Geology and Physiography of West Lancashire and the Mersey Estuary. The author has communicated a paper treating of the same area to the Liverpool Geological Society. It is accompanied by a large coloured map, showing the deposits between the Mersey, Dee, and Ribble; these are the Boulder-clay, Washed-drift sand, Inferior peat and Forest-bed, Formby and Leasowe Marine beds, Superior peat and Forest-bed, and Recent Silts. There are also two plates of horizontal sections and one of vertical sections, all coloured.

REVIEWS

I.—The Geology of Arran and the other Clyde Islands; with an Account of the Botany, Natural History, and Antiquities. By James Bryce, M.A., LL.D., F.G.SS.L. & I. (Glasgow and London: Collins, 1872.)

DR. BRYCE'S serviceable little work—chiefly occupied with the attractive subject of the geology of Arran—has now reached a fourth edition. When a book arrives at this stage, its merits have not been without acknowledgment; it is of more importance, therefore, with all respect to the author, to point out any faults or defects that may still appear in it.

The general succession of rocks in Arran has long been pretty well made out, having been investigated by many able geologists, from the days of Jamieson and McCulloch, down to those of Sedgwick, Murchison, Ramsay, and Lyell. A "central nucleus" of granite, forming the lofty jagged ridge which so arrests the eye from various points of the Firth of Clyde, and which is found to have burst through and uptilted the older stratified rocks in its neighbourhood, consisting of successive bands, more or less entire, of Clay-slate, Old Red Sandstone, and Carboniferous deposits,—so far all is comparatively plain sailing.[1] The two "straits" or difficult passages in Arran geology may be said to be (1) "the two granites," and (2) the "glacial phenomena,"—the one in some respects peculiar to Arran, the other more general, or pertaining also to other localities.

The granite which forms the mountainous district of Arran is found to consist of two kinds,—coarse-grained and fine. Some observers hold that these are mere local varieties of one and the same rock, just as there are similar varieties in other rocks, whether ordinary-stratified, metamorphic, or eruptive; and that, for anything that appears, both are of the same age, having been upheaved subsequently (*how long* subsequently we know not) to the deposition of the Carboniferous strata. But Dr. Bryce, apparently not satisfied with this, proceeds to discuss at considerable length (pp. 21–28) "the relative age of the granites." Let us see, then, what he makes of it.

Apart from the "nucleus," there are in the island two outlying tracts of granite, both of the fine variety, one of which has been erupted amidst Carboniferous strata, and is therefore "clearly of later origin." The other, at no great distance, occurs either in the Old Red, or at the junction of this rock with the Carboniferous strata, rendering its identity of age with the first-mentioned "extremely probable." The granite of the nucleus, however, does not actually come into contact with either the Old Red or Carboniferous rocks; but at those points where it comes *nearest* to them (with a narrow belt of slate intervening), we find these formations uptilted steeply towards it, the Old Red being in some places considerably altered, and the Carboniferous strata overlying it, in general, conformably, or at a corresponding angle of disturbance or elevation. These circumstances, taken along with the fact that there are *no worn fragments of the granite* found imbedded in the sandstones of either formation, seem to yield every proof that the nature of the case admits of, that the upheaval of the granite, whether coarse or fine, was at least post-Carboniferous.

[1] Yet even here a curious mistake has lately been made. In the short article on Arran in Chambers's excellent *Cyclopædia*, we find it stated that "Lias and Oolite lie on the Mica-slate." Well may the student of Arran geology exclaim—

"Far ha'e I travelled and meikle ha'e I seen,
But Lias on the Arran slates never saw I nane!"

Dr. Bryce, alluding to these facts, merely admits that they "*tend to show* that the granite was injected and elevated after the deposit of the old conglomerate." In the next sentence, advancing a step farther, he adds: "Viewing all these facts in connexion with the general conformability of the Carboniferous strata to the Old Red Sandstone, and the gradual transition from the one series to the other observed in several places, it is *even probable* that the injection of the granite took place after the deposit of the Carboniferous formations" (p. 23). But when he goes on to say immediately afterwards, "as the granite of the nucleus is nowhere seen to alter the Carboniferous formations, while it certainly does, as above stated, alter the Old Red Sandstone, it is *quite possible* that these Carboniferous strata may have been deposited upon the Old Red Sandstone during a period subsequent to the irruption of the granite,"—we know not where to find him. After getting the "probable" and "extremely probable" of the case, why go back to the "possible," if, indeed, it be a "possible"?

Summing up at p. 27, "What then, it may be asked, is the conclusion which we favour, and to be finally drawn from these various and somewhat conflicting statements?" In reply, we have an enumeration, under six particulars, of the "various possible conclusions" in the case. For example—

"2. The Old Red Sandstone, and the Carboniferous Sandstones, with their intercalated Limestones and Coal strata, were formed before the granite was exposed to disintegration."

"4. If the granite of the nucleus be thus of later age than the Carboniferous strata, then may all the granites be of one age."

"5. But as the coarse-grained granite cannot with certainty be pronounced newer than the Carboniferous strata, then we may have two ages for these outbursts."

These are certainly "possible conclusions,"—one or other of them is likely to be true! But which of them the Doctor "favours," or recommends to be "finally drawn," remains undisclosed.

Nor is Dr. Bryce in any degree clearer or more satisfactory on the other point to which we have referred, namely, the "glacial phenomena" of the island. Speaking of the transported boulders, he says (p. 41): "We know of only two natural agents capable of producing the effects. These are currents of water and moving masses of ice." But after thus bringing forward two natural agents (allowing this mode of expression to pass as correct) and pronouncing them both "capable of producing the effect," he immediately, in the next sentence, dismisses one of them: "Now the former (*i.e.* currents of water) are *totally inadequate* to carry forward masses of the enormous magnitude found here, or even to transport the lesser blocks over all the obstacles which they have surmounted in their outward course from the parent rock." Currents of water are thus decisively put out of court. Yet a few pages further on, in describing the Corriegills boulder, he says (p. 74): "We have already considered the only possible causes [of its transport], and attempted to estimate the evidence in favour of each. That to which we *chiefly lean* receives support from the case before us. A crowd of lesser blocks surrounds the huge boulder of which we speak,—an association much more likely to occur in the case of *glaciers or bergs* than of currents emanating from a centre so remote." Why, it did not appear that he leant at all to the hypothesis of currents of water,—it was condemned as "totally inadequate." Yet here we have it, as it were, reprieved and brought back again, as a thing not so very unlikely, but having only a balance of probabilities against it. Then it appears, from what Dr. Bryce has just said, that the cause to which he chiefly leaned was "glaciers or bergs." But on turning back to the articles referred to, we find that after being "shut up to the conclusion that the agent was ice in motion," he proceeded to consider the "two ways in which this agency may have been brought into play," viz. floating bergs, and land-ice or glaciers. And he summed up in the following terms: "Our views formerly inclined to the iceberg theory and submarine deposit of the blocks; but a recent careful examination," etc., "have led us to the conclusion that the agency of floating bergs is insufficient to have produced the regularity and persistency which the markings and other evidences of ice action now present, and that an icy envelope in a state of constant advance will alone explain them" (p. 43). After which it *is* exasperating to have "glaciers or bergs" coolly classed together as "the cause to which we chiefly lean."

If Dr. Bryce's footing be thus unstable on the ice, we cannot say that it is firmer or surer on the "Boulder-clay." At p. 44 he writes, "The occurrence of recent shells of arctic species in the deposit called the 'Boulder-clay' shows that in Arran, as on the mainland, a climate prevailed favourable to the development of glaciers." But, as we learn afterwards, the shells do *not* occur in the Boulder-clay, but in certain beds of clay and sand overlying it. The Boulder-clay itself—"the true old Boulder-clay," as he elsewhere states (pp. 183–4)—is, so far as he has yet found, unfossiliferous; and he properly warns those engaged in the study of these superficial formations against "hastily assigning to the Boulder-clay—that is, the lowest and oldest bed—shells or other fossils which may really belong to those which are superior to it" (p. 189). Then, the Boulder-clay, he is of opinion, "may have been formed by land-ice; the shell-bed over it, under and around a rim of ice when the land had been depressed." The shell-clay is thus later than the Boulder-clay, has been formed partly out of it, indicates a different condition of the surface, and is on no account to be confused with it. Yet, as we have seen, he begins by treating it as a part of the Boulder-clay.

Again, looking at the shell-beds in Arran, he finds their elevation above the present sea-level to range from 70 to 180 feet; "so that the greatest depression of which we have any evidence here is 180 feet below the present sea-level, not taking account of the depth required for certain species; and *we hesitate to speak with confidence of any greater depression*" (p. 190). But how does this agree with what we find at p. 46, "That if we can trace an undoubted Boulder-clay deposit up the glens to the height of 1000 or 1500 feet, even if we find no shells, the elevation unquestionably indicates this amount *at least* (author's italics) of former depression" ?[1]

On the whole, we feel constrained to say, the glacial phenomena of Arran have yet to be described. One good paper on Glen Leister, Glenrosa, or Glencloy, would be worth all we have yet had on the subject. Is there no one among our Scottish geologists who will do in this respect for Arran what Professor Ramsay has done so admirably for North Wales? Or, better still, will not the Professor himself, revisiting the scene of his early labours, undertake the congenial task? That would indeed be something for all "glacialists" to look forward to.

Meantime, let us part from Dr. Bryce in good humour: for we are his debtors. An earlier edition of his book—which we still prefer to the present—has been (along with "Ramsay") our companion in many a pleasant ramble over the lovely island of which he treats. And if in what we have written there has been some faultfinding, it is not that we love Dr. Bryce less, but that we love Arran more.

B.

II.—Geological Survey of Ohio. Report of Progress in 1869, by J. S. Newberry, Chief Geologist; with Reports by E. B. Andrews and Edward Orton, Assistant Geologists. (Columbus, 1871.)

Geological Survey of Ohio. Report of Progress in 1870, by J. S. Newberry and Assistants. (Columbus, 1871.)

THE two volumes of Reports now lying before us afford a striking example of the diligence with which the State Surveys are being carried on in America. Containing the results of only two years' investigation, they yet enable one thoroughly to understand the general stratigraphical structure of Ohio, and moreover give, especially in the form of carefully measured sections, a vast amount of local information, which, when it comes to be put into shape in the final Report, cannot fail to prove of the highest value to all interested in the welfare of that State.

The chief matter of interest connected with the geology of Ohio, from a commercial point of view, is undoubtedly the fact that one-third of the region (the south-eastern) consists of profitable Coal-measures, and naturally enough the first efforts of Dr. Newberry

[1] Geological reading at the best is not free from difficulties, but in the page from which we have just quoted we encounter this formidable sentence, "The elevation of the [shell] bed above the present sea-level expresses the amount of former depression below that level." After being fairly baffled with this, and giving it up as a geological riddle, we were relieved to find at p. 190 an acknowledgment that the idea here is "obscurely expressed." But why not have "reformed it altogether" in passing through the press? Another and more serious mistake, which ought surely to have been corrected before publication, is that relating to the height at which the anchor was found in Glenrosa. The statement appears without any note of correction at p. 55, and it is only when we reach p. 166 that we are informed it was totally erroneous! A few other corrections are needful; and some of the illustrations (*e.g.* fig. 21. an "Anticlinal axis") are open to much improvement,—in fact, should either be redrawn or withdrawn altogether.

and his assistants have been spent in elucidating the distribution and arrangement of this formation. Forming the western extension of the great Alleghany Coal-basin, and having a slight general dip to the south-east, it was supposed that many of the coals worked along the eastern border of the State cropped out very soon, and that the seams seen to the west of the Coal-field were carried by the supposed uniform easterly dip so far below the surface as to be practically inaccessible. The present observers have clearly shown that this is not the case. They have proved the existence of at least two gentle folds in the strata running parallel to the strike, the result of which is, that certain good coals or their horizons are within easy reach all along the valleys that cut the north-eastern portion of the basin. The average dip to the south-east is thus shown to be utterly insignificant—not more than three feet to the mile. A further and possibly a less pleasing consequence of the determination of these rolls is, that the Coal-seams which were formerly assumed to exist below the so-called Barren Measures have been reduced to half their former number. It may be noted that a river runs along the bottom of each of these synclinals, the Killbuck and the Tuscarawas.

The entire thickness of the Coal-measures to be found in Ohio is taken at about 1500 feet, in which are ten seams of workable coal. These are of no great thickness, but are of excellent quality. That they are well worth working is shown by the fact, that the annual production of coal in Ohio is 3,000,000 tons. All the coals are bituminous, *i.e.* furnace, coking, and cannel coals,—the coking variety being the most prevalent.

Iron also seems to be plentifully distributed throughout the Coal-measures, in the form of black band and kidney ore, etc., in a manner perfectly similar to that which obtains in Britain. Indeed, no geologist looking over the sections which illustrate this portion of the Ohio Reports, can fail to be struck with the great resemblance they bear to typical ones from our own Coal-fields—say, for example, that of Durham. The same alternation of sandstones and shales, with occasional beds of fire-clay and seams of coal, is to be found in both cases, and the only difference lies in the presence in the American series of one or two beds of Limestone, which, notwithstanding their small thickness, appear to be the most constant.

Immediately below the Coal-measures, Dr. Newberry places a conglomerate, formed chiefly of white quartz pebbles, as the representative of the Millstone Grit. This deposit is, however, often absent; and in its southern portion at least Prof. Andrews is by no means sure that it is anything more than local accumulations of pebbles. Still worse represented is the next great division, that which is equivalent to our Carboniferous Limestone. This consists in Ohio of a calcareous bed known as the "Maxville Limestone," which is shown on the geological map by a few patches of small extent, and far between, along the lower boundary of the Coal-measures and conglomerate, and in the south of the State only.

An important group of rocks, however, next appears, and covers a long strip of country. This is the "Waverley Group," a series of sandstones and grits, conglomeratic towards the middle of the series, and shaly near its base, in all some 640 feet. This important set of beds is supposed to represent the Lower Limestone shales of Europe. The "Upper Waverley" or "Logan Sandstone" as it is locally called, contains several forms of marine plants, but no animal remains. The latter are very scarce throughout this formation apparently, a single indistinct Cyathophylloid coral having been obtained in one layer known as the "City Ledge," and two Brachiopods and some unimportant fish remains in black bituminous shale *near* the bottom of the series.

The lower beds of the "Waverley" contain a considerable amount of mineral oil, which, however, has its origin not in them, but in the "Huron shale" or "Black Slate," which underlies them along most of their course.

This brings us to a point in the stratigraphical structure of the Slate, at which sections of the rocks cropping out in its southern and northern portions respectively would no longer tally. The cause of this is, that several great deposits lying in their proper order along the shores of Lake Erie gradually thin out as their outcrops trend to the south to such an extent as to disappear entirely before reaching the banks of the Ohio, which river forms the southern and south-eastern boundaries of the State. This arrangement will be best understood thus:—

FORMATIONS FROM THE "WAVERLEY GROUP" DOWNWARDS.

	In the North of Ohio.	In the South of Ohio.
	Waverley	Waverley
DEVONIAN	Erie shales	(absent)
	Huron shales	Huron shales
	Hamilton Group	(absent)
	Corniferous Limestone	(absent)
	Oriskany Sandstone	(absent)
SILURIAN	Water-lime and Salina Group	(absent)
	Niagara Group	Niagara Group
	(not at surface)	Clinton Group
	(not at surface)	Cincinnati Group

The "Erie shales" which skirt the lake of that name have been conclusively shown for the first time by the present survey to be the equivalent of the "Chemung Group" of New York Geologists, the characteristic fossils of which (*Spirifer Verneuilii*, *Leiorhynchus mesocostalis*, etc.) have been found in it in considerable numbers.

These beds, 400 feet thick in the north, and absent in the south, form the summit of the Devonian rocks; the oil-producing "Huron shales," which have a continuous outcrop across the State, coming next. In some calcareous concretions occurring near the base of the latter, Mr. Hertzer has recently discovered the remains of gigantic fishes, to the most remarkable of which the name of *Dinichthys Hertzeri* has been applied. Respecting this monster Dr. Newberry says: "This name [Hertzer's terrible fish] will not seem ill-chosen when I say that the fish that now bears it had a head three feet long by two feet broad, and that his under-jaws were more than two feet in length and five inches deep. They are composed of dense bony tissue, and are turned up anteriorly like sledge-runners, the extremities of both jaws meeting to form one great triangular tooth, which interlocked with two in the upper jaw seven inches in length and more than three inches wide. It is apparent from the structure of these jaws that they could easily embrace in their grasp the body of a man—perhaps a horse; and as they were doubtless moved by muscles of corresponding power, they could crush such a body as we would crack an egg-shell."[1]

The "Hamilton Group," the next in descending order, which is well developed in Michigan, was heretofore unknown in Ohio. It is a compound mass of limestones and shales. This, with the Erie and Huron shales, corresponds to our Upper Old Red; whilst the next two, the "Corniferous Limestone" and the "Oriskany Sandstone," are the supposed equivalents of the Devon and Eifel Limestones.

Neither these Devonian rocks nor the Silurians had, up to the dates of the report, been made the subject of such minute study as the formations in the eastern half of the State; but their general trend is sufficiently indicated. Their distribution is entirely dependent on a great anticlinal, the axis of which may roughly be taken as running from near Toledo at the western extremity of Lake Erie to Cincinnati on the Ohio.

The result of this master-fold, and of the subsequent denudation of its summit, is, that in the south-western corner of the State only do all the members as far down as the Cincinnati group crop out. In the north, both that formation and the "Clinton Group" are buried beneath the arch; an island of the topmost beds of the Niagara alone is seen in the form of an inlier immediately along the axis. The "Water-lime and Salina Group" surrounds it on three sides and dips away from it to the west and east. Above this the newer beds once more make their appearance one by one, in the north-west corner, viz. the "Oriskany," the "Corniferous," the "Hamilton," and the "Huron" groups, all dipping to the west.

We have thought it preferable to sketch thus rapidly the geological structure of Ohio as a whole according to the data now afforded us, rather than to dwell on some of the many interesting local details with which these works abound; more especially as the latter are still in their rough state, and will no doubt be more fully discussed in the complete final report. Such are for instance the numerous facts as to the divisions of the Drift in Ohio, concerning which we will only say that none of the authors who treat this branch of the subject seem to find any difficulty in following to a great extent Dr. Dana's theory of the origin of the glacial deposits of that region, as against that so staunchly upheld by Principal Dawson.

One or two facts we must, however, not pass in silence. One is the occurrence in Williams County of two distinct lake beaches, accurately marking contour lines, concerning which more details would be acceptable. The other is, that the old channels now filled with Drift are shown to have been of a much greater depth than

[1] For an account of this Fish, with Woodcut figures, see GEOL. MAG., 1868, Vol. V., p. 184.

that of the existing river-valleys. For instance, "The valley of the Beaver is excavated to a depth of over 150 feet below the present water-level. The trough of the Ohio is still deeper. The Tuscarawas at Dover is running 175 feet above its ancient bed. The rock bottom of the Killbuck valley has not yet been reached." Very few palæontological facts are recorded in these volumes, being reserved for the final Report.

A very clear little geological map and six large sheets of vertical sections (oddly called "maps" also) accompany the Reports we have been noticing. The latter are drawn upon a somewhat new principle —the sheets being crossed by a number of horizontal lines, the space between each representing 10 feet, and all the sections being drawn to the same scale, are so placed that a certain datum bed is on the same line in every case. It is then easy to see at a glance the variations of thickness, etc., each bed or set of beds goes through between place and place.

On the whole, we think that Dr. Newberry and his able assistants have good reason to feel satisfied at having accomplished so much minute and lasting work in so short a space of time, and we look forward with interest to their final report. G. A. L.

Harbottle, 19th September, 1872.

III.—Neues Jahrbuch für Mineralogie, Geologie und Palæontologie. Heft 6, 1870—Heft 2, 1872.

ALL concerned in the progress of Geological knowledge must recognize the high value of this repertory of new facts and new ideas, whether discovered and expounded by our fellow-workers of Germany, or selected and noted by them in this their excellent Mineralogical and Geological Magazine, so well conducted by Professors Leonhard and Geinitz.

The "Jahrbuch" was commenced in 1830, by Professors Von Leonhard and Bronn, and is a well-known work of reference to geologists of all branches. Its original articles have always been of great importance, and its notices of current scientific literature have been indispensable to many a working *savant.*

As formerly, so now, the "Jahrbuch" keeps up its high reputation; and, whilst it successfully labours to advance Mineralogical knowledge, which is cultivated in Germany far more ardently and extensively than in other countries, especially Great Britain, this Journal has always contributed largely to Palæontology, Geognosy, and all other branches of Geology. The following classified notice of the papers that have appeared in the "Jahrbuch" since our last notice of the work (March 1, 1871) will show this very clearly. A. Stelzner: On Quartz and trapezoëdral faces; a paragenetic sketch; and on the Granulite of Saxony. Websky: On the obtuse rhombohedron and hemiscalenoëdron in quartz crystals from Striegau in Silesia. C. Klein: Mineralogical Notes (pl. viii.): 1. Chrysoberyl from the Smaragdum Mines on the Tokowaja; 2. Apatite from the Obersulzbach Valley, in the Pinzgau, and from Poncione della

Fabia, on the St. Gotthardt; 3. Sapphire from Ceylon; 4. Blende from Kapnik; 5. Fahlerz from Horhausen, near Nieuwied; 6. Atakamite from South Australia; 7 and 8. Epidote and Apatite from the Sulzbachthal; 9. The crystallographic terminology of the Hexakisoctaëdron. L. J. Sgelström: New and rare Swedish Minerals. H. Höfer: Minerals of Carinthia: 1. Rosthornite, a new fossil resin; 2. Ilsemannite, a native molybdenum-salt; also the Melaphyre of the Lower Tatra, Hungary (pls. iv. and v.). Th. Peterson: Hydrosulphates of Alumina; 1. Cœruleolactine; 2. Variscite. A. Streng: Felspar Studies (pl. x.). A. Kenngott: Composition of Epidote. K. Th. Liebe: Beyrichite and Millerite. B. Schultze: Crystallized Boracite, and the Formation of Nodules of Boracite in the refuse salt at Stassfurt. P. von Jeremejew; Microscopic Diamonds in the Xanthophyllite of the Schischimski Mountains, Ural (woodcut). Zelger: On Styloliths. Ad. Pilcher: Fossils, Rocks, and Minerals of the Tyrol; 1. The Granite Massif of Brixen; 2. Diorite and Melaphyre near Klausen; 3. Diorite in the Lüsen Valley, etc. H. Rosenbusch: Petrographic Studies on the Rocks of the Kaiserstuhl: 1. The Limburg Rocks (pls. iii. and iv.). A. von Lasaulx: Petrographic Studies on the Volcanic Rocks of Auvergne; 2. Lavas of the Chuquet-Couleyre, etc.; 3. Lavas of the Puy de Pariou, etc. 4. Trachytes of Mont Dore, etc. (pl. xi.). Ferd. Zirkel: Micromineralogical Notices (pl. viii.); 1. "Fluid-enclosures" in Felspar; 2. Crystals in Microscopic "Fluid-enclosures;" 3. Abundance of Apatite in Eruptive Rocks; 4. Leucite with radiate structure; 5. Elæolite; 6. Bischoff's Melted Basalt; 7. Sorby's Melted Syenite of Mount Sorrel; 8. Hauynophyre from Mount Vultur, near Malfi; 9. Smirgel; 10. Microscopic Tridymite; 11. Serpentine Nodules in Marble (with strong mineralogical doubts as to the organic origin of the so-called *Eozoon*): further Notices, 1872 (pl. i.); 1. Chatoyant Obsidian; 2. Basalt from Hamberg, near Bühne; 3. Glass-filled Sandstone in contact with Basalt; 4. Striped Orthoclase. H. Behrens: Preliminary Notice on the Microscopic Constitution and Structure of Greenstones (pl. vii.). H. Credner: North-American Porphyroid-schist (Schieferporphyroide). J. Strüver: Mineral Formations in the Ala Valley, Piedmont. Ch. E. Weiss: *Anomopteris Mougeoti* (woodcut). R. D. M. Verbeek: Nummulites of the Borneo Limestone (pls. i.–iii.), namely:—*N. Pengaronensis*, Verb., *N. sub-brongniarti*, Verb., *N. Biaritzensis*, d'Arch., *N. striata*, d'Orb., var. nov. Of these, the author, writing from Pengaron, states that *N. Pengaronensis* occurs in the lower bed with *Orbitoides Fortisii*, d'Arch.; and that the other three are found together in the Upper Limestone, which abounds with other fossils, including Echinoderms. The last occurs in other places plentifully, together with *N. Ramondi*, Defr., which is not, however, found at Pengaron. *N. Biaritzensis*, however, abounds there, and is thus the only species reaching from the Pyrenees to Borneo. M. Verbeek thinks that the Nummulitic formation will probably be found in Southern Borneo, in Java, and in most of the islands of the great Indian Archipelago. K. G. Zimmerman: A New Species of Deer from the Alluvium of Hamburg (pl. ii.). C. W. C. Gümbel: Preliminary Observations on Deep-sea Mud. L. Würtenberger: The Origin of the Schaffhausen Falls of the Rhine (woodcut). R. Linke: The Constitution and Origin of the Bunter Sandstone Formation of the East border of the Thuringian Basin. C. W. C. Fuchs: The Geological, Microscopical, and Chemical Examination of the old Sedimentary formations in the French Pyrenees, with especial reference to the metamorphosis of these and other old rocks (pl. vii.). The conclusions arrived at (p. 878) are as follows :—1. Between the old sedimentary beds and the granite there is, in many places in the Pyrenees, a seam of metamorphic schist, varying in thickness. 2. The change begins on the border away from the granite in faint traces, and generally becomes stronger as we approach the granite. 3. These stages of the metamorphism are not regular. Highly altered beds have less changed beds between them and the granite; and there are alternations of beds in different degrees of metamorphism. 4. This commences with the separation of small nodules in the clay-schist, which gradually increase in number and size, and at last become andalusite and chiastolite. During the development of these minerals, the rest of the rock changes bit by bit into a confused mass of mica and quartz, with some felspar. 5. Lastly, real mica-schist and gneiss are produced. 6. There are numerous transitions from the gneiss to granite; and throughout this rock, which may be termed "granite-gneiss," there is no actual division between the two in structure. 7. The andalusite and the nodules in the mica-schist and gneiss gradually, through pseudomorphic changes, become mica, and the rocks are thereby so much the richer in that mineral. 8. The cause of the mineral alteration is immediately due to molecular displacements, brought about by chemical interchange of the elementary constituents. 9. The alkaline earths and the abundant iron decrease; and the alkalies and silica increase. 10. The alumina set free by the change of the clay-schist into mica-schist, and further into gneiss, originates the nodules and the segregations of andalusite or chiastolite. 11. The organic material present in the clay-schist diminishes gradually during the processes of change, but can still be recognized in all metamorphic rocks. Cl. Schlüter: Notes of a Geologico-palæontological Journey in South Sweden (chiefly referring to the Chalk Formation). H. J. Burkart: The localities of Mexican Meteorites. C. W. C. Fuchs: The Volcanic Phenomena of 1870. Ferd. von Hochstetter: The Internal Structure of Volcanos, and Miniature Volcanos in Sulphur (three woodcuts). C. Naumann: Mohr's Theory of the Polar Flattening of our Planet. Fr. Pfaff: The Influence of Pressure in Chemical and Physical Processes. P. Groth: The connexion between Crystalline Form and Chemical Constitution. Fr. Klocke: The Growth of Crystals (pls. vi. and ix.).

With this sketch of their varied contents, we direct the attention of our readers to these later numbers of the "Neues Jahrbuch," particularly noticing their richness in exact observations made by lithologist adn mineralogist working with the microscope.

T. R. J.

REPORTS AND PROCEEDINGS.

British Association, Section C., Geology.

Sixth Report of the Committee appointed for the purpose of continuing Researches in Fossil Crustacea—consisting of Prof. P. Martin Duncan, F.R.S.; Henry Woodward, F.G.S.; and Robert Etheridge, F.R.S.

Drawn up by Henry Woodward, F.G.S., etc.

SINCE I had the pleasure to present my last Report, at Edinburgh, I am glad to be able to state that two entire parts (Parts III. and IV.) of my Monograph on the Merostomata have been printed; and form part of the volumes of the Palæontographical Society's annual fasciculus for 1871 and 1872 respectively.

Part III. completes the genus *Pterygotus*, and contains descriptions and figures of

Peterygotus raniceps, Upper Silurian, Lanark.
——— *taurinus.* Upper Silurian, Herefordshire.
——— *ludensis.* Old Red Sandstone, Kington, Herefordshire.
——— *Banksii.* Upper Ludlow, Ludlow.
——— *stylops.* Upper Silurian, Kington, Herefordshire.
——— *arcuatus.* Lower Ludlow, Leintwardine.
——— *gigas.* Downton Sandstone, Hereford.
——— *problematicus.* Upper Ludlow, Ludlow.
Slimonia acuminata. Upper Silurian, Lesmahagow.

Part IV. completes the sub-order Eurypterida, and contains descriptions and figures of the following genera and species:—

Stylonurus Powriei. Old Red Sandstone, Forfar.
——— *megalops.* ,, Ludlow.
——— *Symondsii.* ,, Rowlestone, Herefordshire.
——— *ensiformis.* ,, Forfar.
——— *Scoticus.* ,, ,,
——— *Logani.* Upper Silurian, Lanark.
Eurypterus Scouleri. Carboniferous Limestone, Kirkton, Bathgate.
——— *lanceolatus.* Upper Silurian, Lanark.
——— *pygmæus.* Upper Ludlow, Kington.
——— *acuminatus.* ,, Ludlow.
——— *linearis.* ,, ,,
——— *abbreviatus.* Downton Sandstone, Kington.
——— *Hibernicus.* Old Red Sandstone, Ireland.
——— *Brewsteri.* ,, Arbroath.
——— *scorpioides.* Upper Silurian, Lanark.
——— *punctatus.* Ludlow Rock, near Ludlow.
——— *obesus.* Upper Silurian, Lanarkshire.
——— *Brodiei.* ,, Herefordshire.
Hemiaspis limuloides. Upper Ludlow, near Ludlow.
——— *speratus.* Lower Ludlow, ,,
——— *horridus.* Wenlock Limestone, Dudley.
——— *Salweyi.* Upper Ludlow, Ludlow.

Two doubtful species of *Eurypterus*, namely, *E. mammatus*, from the Coal-measures near Manchester, and *E. ferox*, Coal-measures, Coalbrookdale, and Staffordshire Coal-field, have been examined critically; and with regard to *E. mammatus*, I have also had the great advantage of the assistance, and rare palæobotanical knowledge, of my colleague, Mr. W. Carruthers, F.R.S.

A careful examination of the original specimens of *E. mammatus* has enabled me to show that four out of the six specimens known and referred by the late Mr. Salter to the genus *Eurypterus* are *plant-remains* referable to the genus *Ulodendron*, or to fragments of a large Equisetaceous plant, and that the two remaining parts appear to belong to Jordan and von Meyer's genus *Arthropleura*, a non-descript Crustacean (or, more probably, a gigantic Arachnide), only known at present by a series of obscure fragments from Saarbruck, from Manchester, and from Camerton Colliery, near Bristol.

The ornamentation as well as the form of these pieces are totally unlike any known *Eurypterus*.

Of *Eurypterus ferox* I am now able to state that it is not an Eurypterid, but is referable to Messrs. Meek and Worthen's American genus *Euphoberia*, and that it is a gigantic Myriapod, much larger than our largest tropical living species of Julus or Centipede. This is the second species of Myriapod occurring in the Coal-field of Illinois, U.S., which has since also been obtained in England.

Of the Merostomata only the sub-order Xiphosura remains to be monographed, a task which I hope to complete during the present year.

At the beginning of this year I was requested by Robt. Etheridge, Jun., Esq., F.G.S. (of the Geological Survey of Scotland), to examine some specimens of *Ceratiocaris* from Lesmahagow, Lanarkshire. Among them was one to which he specially drew my attention, as it presented the novel appearance of appendages on the under side of the caudal series of segments. These consist of gill-like plates, depending freely from each segment. They are no doubt analogous to those seen in *Nebalia*, which are supplementary abdominal gill-feet. The discovery of these organs by Mr. Etheridge, which occur also in several other specimens, does not in any way alter the position of *Ceratiocaris*, but renders our knowledge of it more complete.

Since Mr. Salter's paper "On *Peltocaris*, a new genus of Silurian Crustacea," was published in 1863 (Quart. Journ. Geol. Soc., vol. xix., p. 87), I announced a second genus *Discinocaris*, in 1866 (see Quart. Journ. Geol. Soc., vol. xxii., p. 503), also from the Llandeilo flags of Dumfriesshire. Mr. Charles Lapworth, Mr. J. Wilson, Mr. Robert Michie, and others, have added several fine examples of this type of Phyllopodous Crustacea. The largest of these is a portion of a carapace from Dobb's Linn, Moffat, Dumfriesshire, and appears to agree best with *Discinocaris;* but instead of being a carapace the size of a threepenny piece, like *Discinocaris Browniana*, described by me in 1866, this specimen, with its characteristic markings, gives evidence of an individual 7 inches in diameter. Another specimen of this same gigantic phyllopod was obtained from Moffat by Robert Etheridge, Jun., Esq., F.G.S., of the Geological Survey of Scotland.

An entire carapace (of which three examples have been obtained), from the Riccarton Beds, Yads Lynn, near Hawick, makes us acquainted with a new genus, for which the name *Aptychopsis* is proposed.

It measures $1\frac{1}{2}$ inches in length and $1\frac{3}{8}$ of an inch across the carapace.

The nuchal suture is straight (not semicircular, as in *Peltocaris*), and it has a well-marked dorsal suture, which again separates it from *Discinocaris*, in which the dorsal suture is absent.

I name this species *Aptychopsis Wilsoni*, after its discoverer.

Another and more oval-formed but equally perfect carapace of a smaller species, from the Moffat Anthracitic Shales, measuring 8 lines long by 7 lines broad (having the triangular cephalic plate *in situ*), I have named *Aptichopsis Lapworthi*, after Mr. Lapworth, who has devoted so many years to the investigation of the geology of Galashiels and the surrounding district.

A third species, very distinct from the foregoing two, obtained from the Buckholm Beds (which is finely striated concentrically, and is 7 lines in diameter), I have named *Aptychopsis glabra*.

There are several other examples from this rich locality, including specimens of *Peltocaris aptychoides*, species of *Dithyrocaris*, *Ceratiocaris* and portions of the scale-marked integument of *Pterygotus*.

I have lately received from Mr. Thomas Birtwell, of Padiham, Lancashire, two specimens of a new Limuloid crustacean, in which all the thoracico-abdominal segments are welded together into one piece, as in the modern *Limulus*, but without any trace of segmentation along the margin.

The head-shield is also smooth, the compound eyes are small, but the larval ocelli are very distinctly seen, and are almost as large as in the modern king-crabs. The specimen is only 8 lines wide and 8 long, it is remarkably convex in proportion to its size. I have named it after its discoverer *Prestwichia Birtwelli*. (See Geol. Mag., 1872, Vol. IX., p. 440, Pl. X., Figs. 9, 10.)

Another new Limuloid crustacean, specimens of which have been obtained from the Dudley Coalfield, and also from Coalbrookdale, has the five thoracic segments free and movable (as in *Bellinurus bellulus* of König), but the pleuræ are bluntly acuminate, not finely pointed, as in *B. bellulus*, and the head-shield is not armed with long and pointed cheek-spines, as in that species.

I propose to name it *Bellinurus Königianus*, after the distinguished author of the "*Icones Fossilium Sectiles*," formerly Keeper of the Mineral and Fossil Collections in the British Museum. (See Geol. Mag., 1872, Vol. IX., p. 439, Pl. X., Fig. 8.)

Of foreign Palæozoic Crustacea, a remarkable new Trilobite (obtained by Dr. W. G. Atherstone, of Graham's Town, Cape Colony), from the Cock's Comb Mountains, South Africa, deserves to be noticed here. It is a new and elegant species of *Encrinurus* (measuring three inches in length), preserved in the centre of a hard concretionary nodule, which has split open, revealing the Trilobite itself in one piece and a profile of it on the other. The profile shows that each of the eleven free body-segments was armed with a prominent dorsal spine nearly half an inch in length, whilst the pygidium was similarly terminated by an even longer spine, slightly recurved at its extremity, and all of the spines *annulated*, as if composed of a large number of *joints*. *Encrinuri* with two (and in one case even with *three*) dorsal spines have been obtained in considerable numbers, both at Dudley and Malvern, and may be seen in Dr. Grindrod's collection, and in the British Museum and many other places; but a Trilobite with such an array of long dorsal spines as is presented by this African species is very remarkable, and for an *Encrinurus* quite unique. I have named it after its locality *E. crista-galli*, which is doubly appropriate. (See Proceedings Geol. Soc. Lond., Nov. 20, 1872.)

Among the specimens sent me up by Mr. Birtwell from Lancashire, from the *Ironstone* of the Coal-measures (so rich in organic remains), was one not referable to the Crustacea.

On examination it proves to be a new and very remarkable Arachnide, referable to the same genus as one described by Mr. Samuel Scudder, of Boston, U.S., from the Illinois Coal-field, under the name of *Architarbus* (see Meek and Worthen's Report on the Geology and Palæontology of Illinois).

I have named it *Architarbus sub-ovalis*. (See GEOL. MAG., 1872, Vol. IX., p. 385, Pl. IX.)

This is the second British Arachnide I have lately obtained from the Ironstone of the Coal-measures.

Tertiary Crustacea.— Some time since I described two new forms of Crabs [1] from the Lower Eocene, Portsmouth, discovered by Messrs. Meyer and Evans in the excavations for the New Docks there. More recently I have received a fresh series, from which I have been enabled not only to re-figure and to fully describe the species named by me (on December 21st, 1870) as *Rhachiosoma bispinosa*, and to show both the upper and under side of the male and female, but also to record two additional forms for which I propose the genus *Litoricola*, naming them respectively *L. glabra* and *L. dentata*. These do not belong (like *Rhachiosoma*) to the *Portunidæ*, but to the *Ocypodidæ*, or true shore-crabs, their legs being adapted for running, and their eyes furnished with long peduncles.[2] (See Proceedings Geol. Soc. Lond., November 20, 1870.)

This series of Crustacea (though they are exceedingly brittle and delicate) are remarkable for the perfect state of preservation in which they occur, so that we are able, in each case, to restore nearly the entire animal. Of the two new ones, it is interesting to record that they afford evidence of unmistakable land conditions, both of them being shore-dwellers, and adapted for running on the old muddy and sandy beaches of the pre-Eocene Continent. The sections still, I believe, open at Portsmouth, deserve an inspection from all who are interested in the stratigraphical geology of this series of deposits.

Miocene Crustacea.—Having been requested by Dr. A. Leith

[1] *Rhachiosoma bispinosa* and *R. echinata*. See Quart. Journ. Geol. Soc., 1871, vol. xxvii., p. 91, pl. iv.

[2] Under the name of *Goniocypoda Edwardsii*, I described a *true* Eocene shore-crab from the Red Marl of the Plastic Clay, High Cliff, Hampshire, in December, 1867. See GEOL. MAG., Vol. IV., p. 529, Pl. XXI., Fig. 1.

Adams, F.R.S., to examine and describe a series of Crustacean remains from the Miocene of Malta, collected by him in that island, I have done so, and find them to include *Scylla*, *Ranina*, *Portunites*, *Maia*, *Atergatis*, and perhaps *Neptunus*. The *Scylla* agrees specifically with the *Scylla serrata* found in the Indian seas of to-day and in the Tertiaries of the Philippine Islands. This is one of the species of fossil crabs so largely imported into China as "Medicine-Crabs" (see Mr. D. Hanbury's papers read before the Pharmaceutical Society, and published in their Journal, February, 1862, *et seq.*).

The *Ranina* is distinct from any recorded species, and I have therefore to propose for it a specific name. I dedicate it to its discoverer (*R. Adamsi*).

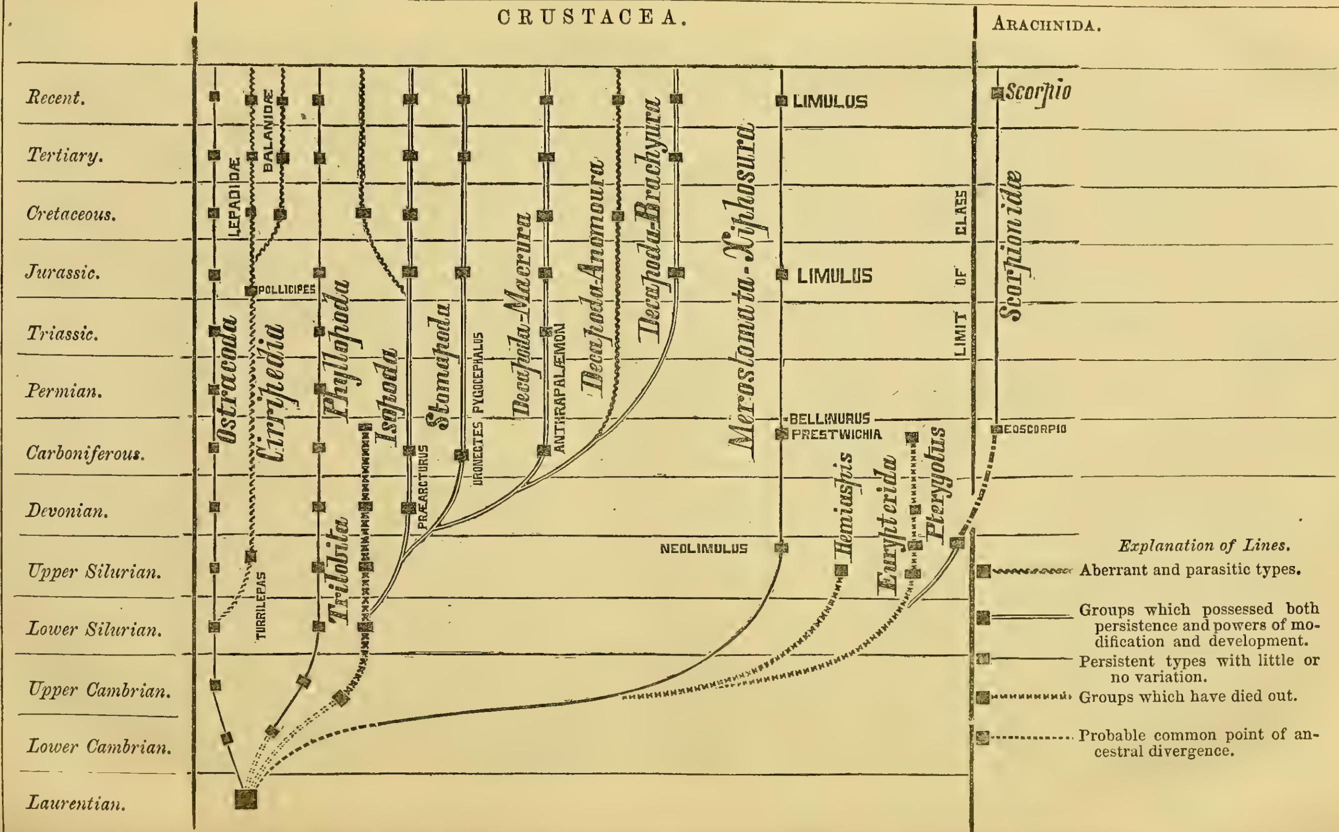
The occurrence of these Eastern forms, with the remarkable Echinoderms of Asiatic type, in Malta, clearly indicate the former extension of an Indian Fauna as far east as the Mediterranean, if not to our own shores.

Whilst still pursuing the subject of the structure of the Tribolites, no new facts have been collected, but much has been done in the examination of larval Limulus, the substance of which I have summarized in a paper read in December last before the Geological Society. (See Quart. Journ. Geol. Soc., 1872, vol. xxviii., p. 46.)

Dr. Anton Dohrn, without (as I think) any very clear reason, proposes to separate the Xiphosura and the Eurypterida, and also the Trilobita, from the Crustacea, on the ground that they do not, so far as we are at present aware, pass through a Nauplius stage, but the young are like the parents save in the fewer number of their somites. He is, however, unprepared to say they are Arachnides, so that he can only place them in a group intermediate between the Arachnida and Crustacea (the Gigantostraka of Heckel). Against this course I have protested on the grounds that if we take away the Trilobita from the pedigree of the Crustacea, one of the main arguments in favour of evolution to be derived from this class, so far from being strengthened, is destroyed. From what are the Crustacea of to-day derived? Are we to assume that they are all descended from the Phyllopods and Ostracods, the only two remaining orders whose life-history is conterminous with that of the Trilobita? Or are we to assume that the Arachnida are the older class? "If," as Fritz Müller well observes, "all the classes of the Arthropoda (Crustacea, Insecta, Myriopoda, and Arachnida) are indeed all branches of a common stem (and of this there can scarcely be a doubt), it is evident that the water-inhabiting and water-breathing Crustacea must be regarded as the original stem from which the other (terrestrial) classes, with their tracheal respiration, have branched off." ("Facts and Arguments for Darwin," p. 120).

The accompanying Table is merely intended as an attempt roughly to indicate (according to our present knowledge of the earliest appearance in time of the several orders of Crustacea) the most probable manner in which the various groups were evolved from a common pre-Cambrian parent-stock. I have specially distinguished those which are merely persistent types, but incapable of modifica-

Range and Evolution of the Several Orders of CRUSTACEA in Time.



tion from those which were capable both of persistence and modification; and these again from the inadaptive types which have died out. The aberrant and highly specialized parasitic types appear last in time, and mark the culminating point of the Crustacea when conditions prevailed more highly favourable to the class than at any earlier period.

Geological Society of London.—November 6, 1872.—Prof. Ramsay, F.R.S., V.P., in the Chair.—The following communications were read:—1. "A Report by F. T. Gregory, Esq., Mining Land Commissioner in Queensland, on the recent discoveries of Tin-ore in that Colony." Communicated by the Right Hon. the Earl of Kimberley, Secretary of State for the Colonies.

According to this report, the district in Queensland in which tin-ore has been discovered is situated about the head-waters of the Severn river and its tributaries, comprising an area of about 550 square miles. The district is described as an elevated granitic table-land intersected by ranges of abrupt hills, some attaining an elevation of about 3,000 feet above the sea. The richest deposits are found in the beds of the streams and in alluvial flats on their banks, the payable ground varying from a few yards to five chains in extent. The aggregate length of these alluvial bands is estimated at about 170 miles, the average yield per linear chain of the stream-beds at about ten tons of ore (cassiterite).

Numerous small stanniferous lodes have been discovered, but only two of much importance, namely, one near Ballandean Head Station on the Severn; and another in a reef of red granite rising in the midst of metamorphic slates and sandstones at a distance of about six miles. The lodes run in parallel lines bearing about N. 50° E.; and one of them can be traced for a distance of nine or ten miles. The ore, according to Mr. Gregory and Mr. D'Oyly Aplin, is always associated with red granite, *i.e.* "the felspar a pink or red orthoclase, and the mica generally black; but when crystals of tin-ore are found *in situ*, the mica is white." The crystals of tin-ore are generally found in and along the margins of quartz threads or veins in bands of loosely aggregated granitoid rock, but are sometimes imbedded in the micaceous portions. The report concludes with some statements as to the present condition and prospects of the district as regards its population.

2. "Observations on some of the recent Tin-ore Discoveries in New England, New South Wales." By G. H. F. Ulrich, Esq., F.G.S.

The district referred to by the author is in the most northern part of the colony of New South Wales, almost immediately adjoining the tin-region of Queensland described in the preceding report. It forms a hilly elevated plateau, having Ben Lomond for its highest point, nearly 4,000 feet above the sea-level. The predominant rocks are granite and basalt, inclosing subordinate areas composed of metamorphic slates and sandstones; the basalt has generally broken through the highest crests and points of the ranges, and spread in extensive streams over the country at the foot.

The workings of the Elsmore Company, situated on the north-west side of the Macintyre river, about twelve miles E. of the township of Inverell, include a granite range about 250 feet in height and nearly two miles in length. The granite of the range is micaceous, with crystals of white orthoclase, and is traversed by quartz-veins which contain cassiterite in fine druses, seams, and scattered crystals, and by dykes of a softer granite, consisting chiefly of mica, and with scarcely any quartz, in which cassiterite is distributed in crystals, nests, and bunches, and also in irregular veins of several inches in thickness. This granite yields lumps of pure ore up to at least 50 lbs. in weight. The quartz-veins contain micaceous portions which resemble the "Greisen" of the Saxon tin-mines. The deepest shaft sunk in one of the quartz-veins was about 60 feet in depth. The author noticed certain minerals found in association with the tin-ore, and the peculiarities of the crystalline forms presented by the latter.

The drift is very rich, and consists of a generally distributed recent granitic detritus, from 6 in. to 2 ft. thick, and of an older drift (probably Pliocene) capping the top of the range, and probably dipping beneath the adjoining basalt. The washing of the granite detritus gives from 3 ozs. to more than 2 lbs. of ore per dish (of about 20 lbs.). The older drift is rather poor in tin to within about a foot of the bottom; but the bottom layer is in part very rich, some having yielded as much as 6 lbs. of ore per dish.

The author also described the Glen Creek, about 40 miles north of the Elsmore mine, from the surface deposits of which tin-ore has been obtained by washing. The course of the creek is mostly through a black hard slate destitute of fossils; but at one part, for about 10 chains, its bed consists of a fine-grained hard granite, with numerous veins of arsenical and copper pyrites, and one solid vein of tin-ore, about $\frac{3}{4}$ in. in thickness, all of which pass from the granite into the slate without any interruption or change, the passage from one rock into the other being also gradual.

The chief underlying rock of the district is a black slate, but dispersed through it are small outcrops of a rather coarse-grained micaceous granite, close to one of which several veins of solid tin-ore, from 1 to 4 inches thick, have been found traversing the slate rock. The tin-ore disseminated through the surface-deposits has been derived from these veins and from a very hard and tough greenstone (diabase), which occurs in large dykes and patches in various places, and is probably younger than the granite.

In conclusion the author referred to the probability that a deficiency of water may prove a great obstacle to the full development of the tin-mining industry in this district, but stated that "it seems not unlikely that the production of tin-ore from this part of Australia will reach, if not surpass, that of all the old tin-mining countries combined."

Discussion.—Mr. Daintree commented on the enormous value of the 170 miles of frontage for stream-tin works exposed in Queensland. The value of these alone would, according to Mr. Gregory's calculation, be some £13,000,000; taking an equal value for those of New South Wales, there would be lying on the surface something like twenty-five times the whole amount of tin annually produced in Cornwall. In addition to this, there were lodes of immense length and richness. At the same time there were large tracts of similar granite to that containing the stanniferous veins still unexplored in other parts of Queensland. What amount also of tin-bearing drift might exist under the tracts of basalt was still unascertained. The tin and other minerals were, he observed, limited to the palæozoic and metamorphic districts traversed by dykes, such as those mentioned in Mr. Ulrich's paper; and although very large areas of granite similar to that of the Severn river were to be found in other parts of Queensland and Australia, the stanniferous portions would be confined to the areas traversed by such dykes.

3. "On the included Rock-fragments of the Cambridge Upper Greensand." By W. Johnson Sollas and A. J. Jukes-Browne. Communicated by Prof. Ramsay, F.R.S., P.G.S.

The occurrence of numerous subangular fragments in the Upper Greensand formation was so far remarkable that it had already attracted the notice of two previous observers (Mr. Bonney and Mr. Seeley), who had both briefly hinted at the agency of ice. While ignorant of the suggestions of these gentlemen, the authors of this paper had been forced to the same conclusion. A descriptive list had been prepared of the most remarkable of the included fragments. The infallible signs of the Upper Greensand origin consisted in incrustations of *Plicatula sigillum, Ostrea vesiculosa,* and "Coprolite," without which, it was stated, the boulders would be undistinguishable from those of the overlying drift. The following generalizations were then put forward:—

1. The stones are mostly subangular; some consist of friable sandstones and shales, which could not have borne even a brief journey over the ocean-bed.

2. Many are of large size, especially when compared with the fine silt in which they were embedded; the stones and silt could not have been borne along by the same marine current.

3. The stones are of various lithological characters, and might be referred to granitic schistose, volcanic and sedimentary rocks, probably of Silurian, Old Red Sandstone, and Carboniferous age.

Such strata are not found *in situ* in the neighbourhood, and the blocks must have come from Scotland or Wales. Numerous arguments were adduced in favour of their Scottish derivation.

The above considerations, that numerous rock-fragments, some of which are very friable, have been brought from various localities and yet retain their angularity, were thought sufficient evidence for their transportation by ice; the majority showed no ice-scratches, but the small proportion of scratched stones in the moraine matter borne away on an iceberg, and the small percentage of ice-scratched boulders in many deposits of glacial drift, show that the absence of these striæ is not inconsistent with the glacial origin of the included fragments. Besides this the stones of the Greensand consisted of rock, from which ice-marks would readily have been removed by the action of water. The authors stated, however, that they had found more positive evidence in a stone which was unmistakably ice-scratched, consisting of a siliceous limestone, and preserved in the Woodwardian Museum. The fauna, so far as it proved anything, suggested a cold climate; though abundant, the species were dwarfed, in striking contrast to those of the Greensand of Southern England and the fauna of the succeeding Chalk. The authors concluded that a tongue of land separated the Upper Greensand sea into two basins, the northern of which received icebergs from the Scottish-Scandinavian chain; the climate of this was cold, that of the southern basin much warmer.

Discussion. — Mr. Seeley gave some history of the specimens in the Woodwardian Museum, on which the paper was partly founded, some of which had been collected by the late Mr. Lucas Barrett, and others by himself. He thought that some of the scratches on one of the specimens from Grantchester might be of modern origin, and doubted whether the place of derivation of most of the blocks was Scotland. Besides the rocks mentioned, he had found fragments of Magnesian-limestone and columns of *Poteriocrinus*. He could not agree with the authors as to the physical geography of Britain during the Upper Greensand period. He considered that it was from the denudation of the great barrier mentioned in the paper that much of the material of the Upper Greensand was derived; and disputed the value of conclusions as to climate founded on so small an area of induction.

Mr. Walker did not agree with the author as to the absence of large Ammonites in the Cambridge Greensand, and of fossils in the Gault of the neighbourhood of Cambridge; the latter had been found by Mr. Keeping at Upware. He inquired in what state of combination the phosphoric acid was supposed to be brought from Scotland.

Mr. Sollas, in reply, pointed out the angularity of some of the specimens, such as to him seemed inconsistent with any other means of transport than that of ice, and the difficulty attending the supposition that the blocks were derived from any other than a northern source. He thought that the large Ammonites were derived from a lower bed in the Gault than the upper point, from which he had supposed a large portion of the Upper Greensand fossils had been derived. He considered that the phosphoric acid had been conveyed along the sea-bottom, combined with some base, and that the combination was in a comminuted condition.

Mr. Jukes-Browne also replied, and pointed out that in his view the London and Harwich anticlinal had been covered with a great thickness of Gault at the time of the deposit of the Upper Greensand.

Prof. Ramsay, in winding-up the discussion, expressed an opinion that the forms of pebbles of glacial origin might be recognized by an experienced eye even though the striæ had been worn off, and that some of the pebbles exhibited showed traces of such an origin. He called attention to the fact that the deposit of glaciated pebbles in any particular locality did not in any way involve the existence of arctic conditions at that spot, though they might exist elsewhere.

Geologists' Association.—November 1st, 1872.—The Rev. T. Wiltshire, M.A., F.G.S., etc., President, in the Chair.—"On the Influence of Geological Reasoning on other Branches of Knowledge." By Hyde Clarke, Esq., D.C.L. After referring to his paper at the installation of the Association, "On Geological Surveys," Mr. Clarke said there was a direct and indirect action produced by geology, which had operated remarkably on the substance and modes of thought in the present day. Being a science of observation, it had tended to confirm the practice of observation. The determination of stratification of itself exercised a potent effect on modern thought, because with it were connected the ideas of succession and progression. Reasoning by analogy will always prevail in things human against all objectors, because, after all, as in things human the mind recognizes symmetry, so reasoning by analogies becomes reasoning by probabilities. Thus, the analogies of stratification, and its palæontological relations, affected natural history, and indeed most branches of philosophy. The nomenclature of geology was applied to political discussions, and carried even into the columns of journals and periodicals. A consequence of stratification, mineralogical and palæontological, in extension of succession, is the acknowledgment of the passage of greater epochs of time than had been heretofore admissible in history or chronology. Thus, too, the range of the infinite in space, extended by the investigation of the fixed stars, was fortified by the element of the eternal in time. This contemplation affected not only the early narrations of the historian, but it also gave evidence of fixity and stability in the conditions of the universe. After alluding to the testimony as to the relations of light afforded by the eye of the *Trilobite*, the support given by geology to the speculations of the natural philosopher was mentioned in the examples of the powers of water, fire, and electro-magnetism, and their connexion with the phenomena of the universe, as illustrated by late investigations of the sun's photosphere, of meteors, and comets. Geography has had to regard the effects of the past and the present, and to consider the connexion of countries by their strata and mineral relations, and also the distribution of plants and animals. The fossil marine fauna and flora were the introduction to what is yet to be discovered at the bottom of the ocean. Thus, geology anticipates geography and natural history, and gains a forecast of events. Meteorology has expanded its range to embrace a knowledge of the vicissitudes and changes of climate, which have left the vestiges of glacial action in the tropics and planted tropical remains in the polar regions. As the bonds of restriction of thought by prejudice are loosened, and our grasp gains in freedom, the dreams of the past acquire consistency. We have seen the dragons of folk-lore, and have found the abodes of the man-eating ogres, and handled their weapons and tools. It is in philosophy, including theology, that the effect of geological discussions may most clearly be discovered. The English on both sides of the Atlantic have more especially promoted these discussions and the advance of geological studies, which in their early contests against prejudice could be best cultivated under free institutions. The conflict with the schools of theological interpretation has most usefully taken place in those countries where the subjects were exposed to the investigation and examination of men, compelled to give a reason for their faith. In theology a salutary breadth had been given to the interpretations of historical portions of the Scriptures, and the canon which divides the domain between science and theology had been re-enacted. The course of geology has influenced those sects of thought into which in all time men have been divided. Its facts and teachings have been adopted by those who accept the perpetual succession of matter, and have led to most brilliant speculations, for the development of which, by great men of science, the students of the world anxiously await. To the other school, of those who acknowledge evidences of design, geology affords, in its facts, abundant confirmation. Ethnology, in its subject of men, is the nobler science and earlier in its traditions, but it has been greatly favoured by the advance of geology, and is thereby acquiring the claims of an exact and recognized department of science; whatever its development, the mode of reasoning adopted must ere long be acted upon by that worked out in geology.

CORRESPONDENCE.

BOULDER CLAY (?) IN DEVONSHIRE.

SIR,—Rapid traverses and hasty observations have been rather severely criticized in a recent number of your MAGAZINE; but it is possible that even in a hurried visit one may make some useful suggestion. During a recent erratic traverse I saw what I took to be Boulder Drift in Devonshire. Coming from South Wales to Tiverton by way of Worcestershire, I was much struck with the similarity of some of the drift deposits in that part of Devonshire to those boulder beds which obscure a great part of the country between Cardiff and Bridgend, where I was engaged for some time, and often with much "scientific use of the imagination," in completing the re-survey of the southern part of Glamorganshire, which was chiefly done by Mr. Bristow. The deposits in both areas are made up of what may be local materials, at any rate they have not come from far, being large boulders of Carboniferous sandstones and grits, quartz, and Old Red Sandstone. Those in South Wales are clearly of glacial origin. May we not, therefore, look upon these deposits in Devonshire which possess an identity in character as being of similar origin? These are, of course, the ordinary river gravels as well in these parts; but the position of some of the deposits in many places near Tiverton, which were pointed out to me by Mr. Ussher, forbids any notion of their being due to the action of rain and rivers: they seem to have been deposited after the land obtained its present general features, and being irrespective of any level, occupying the highest ground, and sometimes coating the hills, as they are coated in South Wales, we can see no traces of marine action in their formation. Some of the gravels and boulder beds near Tiverton are no doubt very largely made up of old Triassic conglomerates.

Although this is only a suggestion, it may be interesting to bring it forward, as the evidence of Glacial deposits in the south-west of England has received some little attention. Some years ago Mr. Ormerod ascribed a glacial origin to some "old gravels" in the valley of the Teign. (GEOL. MAG. Vol. VI., 1869, p. 40.) Mr. Mackintosh had previously observed what he thought might be glacial scratches on some exposures of Mountain Limestone "near the summit of the hill to the north of Axbridge," Somerset (GEOL. MAG. Vol. III. 1866, p. 574); and very recently Mr. Perceval has given a note on a Boulder found near Old Cleeve, West Somerset. (GEOL. MAG. April, 1872, p. 177). Mr. Moore, too, sees evidences of glaciation around Bath (Bath Nat. Hist. and Antiq. Field Club, March 10, 1869).

QUEEN CAMEL, 23*rd September*, 1872. HORACE B. WOODWARD.

P.S.—Mr. Bristow tells me that he and Professor Ramsay found Coal-measure sandstones with glacial striæ in the Boulder-clay near Cardiff, and that having seen the drift on Exeter Hill near Tiverton, he remarked to Mr. Ussher, who was engaged in mapping the district, that striæ should be looked for, as polished gravel such as that was very suggestive of glacial action. H. B. W.

MR. HOPKINSON'S NEW SPECIES OF GRAPTOLITES FROM THE SOUTH OF SCOTLAND.

Sir,—While gratefully acknowledging the value of Mr. Hopkinson's researches among the graptolites of the south of Scotland, I beg to enter my protest against part of his paper in the November number of the Magazine.

At p. 501, Vol. IX., it is stated that "The Lanarkshire graptolitic shale is considered by Prof. Geikie to form 'an upper part of the Moffat group,' but while decisive stratigraphical evidence is wanting, from the evidence afforded by the fossils it seems more probable that but one band of graptolitic shale runs through the Llandeilo rocks of the south of Scotland, there being in this band several distinct zones, each marked by a different assemblage of fossils, but with many species in common."

During the progress of the Geological Survey in the Leadhills district, "decisive stratigraphical evidence" was obtained that the Leadhills graptolitic shale group occupies a higher horizon than the Moffat group. This is indicated in the Explanation of Sheet 15 of the Geological Survey Map.

From the localities given in Mr. Hopkinson's paper, it appears that of the ten new species of graptolites described by him, two are peculiar to the Moffat group, six peculiar to the Leadhills group, and two common to both. There is not, here at least, much "evidence afforded by the fossils" of the identity of the two groups. What I object to on Mr. Hopkinson's part is his describing the whole ten new species as "graptolites from the Moffat group," thereby mixing up fossils which it is of the utmost importance to keep separate. I am confident that neither Professor Geikie, nor either of my colleagues, Messrs. Horne and Skae, who have since the survey of the Leadhills group carried on the work into the Moffat group, would for a moment entertain the idea of their identity.

Even where there really is an absence of stratigraphical evidence, it seems to me that the best course is not to slump together all the fossils collected within a certain area and call them a "group," but to distinguish the fossiliferous rocks bed by bed, if need be.

Of the localities in question a glance at Sheet 15 of the Geological Survey Map will show the following to be in the Leadhills group, viz., Wanlock Water, Kirk Gill, Lowen Dod, and Laggen Gill. Lochan Burn, Frenchland Burn, Garple Linn, and Moniave (?) probably lie within the limits of the Moffat group. I trust, therefore, that pending the issue of the Geological Survey Memoir on the holew

Southern Silurian region, Mr. Hopkinson will accept the undernoted grouping of the new species :—

MOFFAT GROUP,—
Corynoides gracilis.
Graptolithus acutus.
LEADHILLS GROUP,—
Dendrograptus ramulus.
Diplograptus Etheridgii.
——— *pinguis.*
Diplograptus fimbriatus.
——— *Hincksii.*
Dicranograptus rectus.
COMMON TO MOFFAT AND LEADHILLS GROUP,—
Graptolithus attenuatus.
Diplograptus penna.

GEOLOGICAL SURVEY,
ALEXANDRIA, 11 *Nov.*, 1872.

R. L. JACK.

THE DIVINING ROD IN ESSEX.

SIR,—Mr. H. B. Woodward's surprise as to the existence of a belief in the powers of the Divining Rod will, I think, give way as he finds it is much more firmly believed in by west-country people than is commonly imagined. A few days ago I was travelling in company with a gentleman to whom I had been introduced, who is a civil engineer and architect. He was telling me of some borings he had to conduct in Essex, in the London-clay, for water. I immediately referred him to Mr. W. Whitaker's recently published memoir on the London Basin, in which is given such a copious list of well and other borings, thinking these might help him. I was replied to with a smile of self-satisfaction, and presently informed that when he wished to find water, he always used a forked hazel wand, which plainly and distinctly "turned in his hand" in the direction where water lay, and that he had never known this plan to fail! My purpose in writing is to recommend the practice to the Geological Survey, so that a corps of hazel-wand explorers might be formed and drilled! It would be a novelty to have a "Professor of the Divining Rod" at Jermyn Street!

IPSWICH. J. E. TAYLOR.

CORALLINE CRAG FOSSILS.

SIR,—As Dr. Allman has not confirmed the statement made in the GEOL. MAG. (antè p. 337) respecting the presence of *Purpura lapillus* in the Coralline Crag, I presume the name of that species cannot be introduced into my Catalogue.

Hydractinia is a fossil not very rare in the Coralline Crag, and I have also found it in the Red Crag, but in this latter formation it is possibly a derivative from the older bed. The shell this Hydroid has generally selected for investiture is *Trophon consociale* (Crag Moll., vol. i., p. 49, tab. vi. f. 11): a specimen now in my possession has nearly half the shell exposed. This fossil has been long known, and the name of it was inserted in my "Catal. of Zoophytes from the Crag" (Ann. and Mag. Nat. Hist. vol. xiii. p. 21, 1844), as *Alcyonidium circumvestiens.* The generic name *Alcyonidium*, Lamouroux, was adopted by Dr. Geo. Johnston in his work on the British Zoophytes, where, at p. 304, he describes *Alcyonium echinatum* of Montague and Fleming, and of which a very indifferent and incorrect figure is given. He there speaks of the papillæ as "arranged in rows," but those upon the fossil not having that regularity, and apparently larger and comparatively fewer in number, as well as having the layers in some parts (from successive generations) of nearly half an inch in thickness, I thought it might be specifically distinct. I have, however, since then obtained a recent specimen covering a dead shell of *Natica catena*, on which the papillæ are not in rows, but irregular, like those upon the Crag fossil. Its correct specific determination must be left for future observers. SEARLES V. WOOD.

INDEX.

ALLMAN, G. J., Notice of a Fossil *Hydractinia* from the Coralline Crag, 337.
Allport, S., On the Microscopic Structure of the Pitchstones of Arran, 536; Source of Volcanic Products, 188.
American, North, Glacial Deposits, 69.
Antholithes, 52.
Anthrotaxites, 193.
Appalachians, Geognosy of the, 76.
Arachnide from the Coal-measures, 385.
Araucarites Häberleinii, 150.
Arenig rocks, Graptolites of the, 467.
Arran, Pitchstones of, 1, 536; Geology of, 552.
Atolls, 329.
Australia, Metalliferous Deposits in, 88, 335.
Austro-Hungarian Coal Supply, 235.
Aveline, W. T., Silurian Strata of the Lake District, 441.

BAILY, W. H., Fossil Flora of Ireland, 90.
Balfour, G. W. and F. M., On the Geology of the East-Lothian Coast, 161.
Banbury, Geology of, 279.
Bath Oolites, Denudation of the, 190.
Battersea, Section at, 187.
Beesley, T., Geology of Banbury, 279.
Bell, A., The Succession of the Crags, 209; *Corbicula fluminalis*, 430; *Unio limosus* in the Crag, 431.
Bellinurus, 439.
Bendigo Gold-field Registry, 328.
Biluchistan, Geology of, 475.
Binney, E. W., Flora of the Carboniferous Strata, 326.
Black, W. T., Grooved Boulders in Diluvial Clay, Edinburgh, 321.
Blake, J. F., Infralias in Yorkshire, 137.
———, J. H., and H. B. Woodward, Relations of the Rhætic Beds to the Lower Lias and Keuper Formations in Somersetshire, 196.
Blanford, W. T., Geology of Biluchistan, 475; Geology of Orissa, 476.
Bleasdell, W., Modern Glacial Action in Canada, 330.
Bonney, T. G., Terraces in Norway, 48; Chloritic Marl of Cambridge, 143; Ice Scratches in Derbyshire, 269; On Certain Lithodomous Perforations in Derbyshire, 315; Notes on the Roslyn Hill Clay Pit, 403.
Botany, Contributions to Fossil, published in England in 1871, 369.
Boulder-clay in Cheshire, 330; in Devonshire (?), 574.
Boulder near Old Cleeve, West Somerset, 177.
Boulders, Conservation of remarkable, 176.
———, Grooved, in Diluvial Clay, Edinburgh, 321.
Bristol Naturalists' Society, 528.
British Association, 463, 563; List of papers read in Section C., 428.
Bryce, J., Geology of Arran, 552.
Busk, G., Mammalian Remains from Acton, etc., 380.
Butterfly, New Fossil, 532.

CALCAREOUSLY-INCRUSTED Stones in Drift, 144.
Cambrian and Silurian rocks, Classification of the, 383.
Cambridge, Phosphatic Nodules of, 331; Upper Greensand of, 143, 332, 571.
Canada, Glacial Action in, 330.
Cannington Park Limestone, 94.
Cape Colony, Devonian Fossils from, 41.
Carboniferous Strata, Flora of the, 325.
Cardiocarpon, 55.
Carpenter, W. B., On the Temperature and other Physical Conditions of Inland Seas, 545.
Carruthers, W., Notes on some Fossil Plants, 49; Review of the Contributions to Fossil Botany published in Britain in 1871, 369; Tree-ferns of the Coal-measures, 465.
Carter, J., On *Orithopsis Bonneyi*, a New Fossil Crustacean, 529.

Cervidæ of the Forest-bed of Norfolk and Suffolk, 374.
Cetiosaurus, 42.
Chalk of Antrim, 334; of Norfolk, 430.
Chalk Rock, near Salisbury, 427.
——, White, Divisions of the, 469.
Chandler, C. F., Lecture on Water, 477.
Cheshire, Boulder-clay in, 330; Post-glacial Geology of, 552.
Chloritic Marl of Cambridge, 143.
Cirques, Formation of, 10, 93.
Clarke, H., Geological Reasoning, 572.
Climate, Changes of, during the Glacial Epoch, 23, 61, 105, 164, 215, 254.
—— of the Post-glacial Period, 153.
Coal-fields of India, 32, 476.
—— measures, Tree-ferns of the, 465.
—— supply, Austro-Hungarian, 235.
Cœlacanthus Harlemensis, 31.
Colliery Explosions and Weather, 324.
Collins, J. H., Mineralogy of Cornwall and Devon, 96.
Condylites, 195.
Coniferous Remains from Solenhofen, 150, 193.
—— Wood, Fossil, 57.
Coombs, J. A., Section at Battersea, 187.
Corbicula fluminalis, 430.
Cornet, F. L., and A. Briart, Divisions of the White Chalk, 469.
Crag, Coralline, *Hydractinia* from the, 337.
——, Man in the, 247.
—— Mollusca, 326.
——, Red, *Trochocyathus anglicus* from the, 378.
——, *Unio limosus* in the, 431; *Purpura lapillus* in the, 431.
Crags, Succession of the, 209.
Crayford, Worked Flint from, 268.
Croll, J., Award of the Wollaston Donation Fund to, 142.
Crustacean, New British, 144, 529.
Crustacea, Palæozoic, 433.
—— Report on, 563.
Cupressocrinus, 387.

DAINTREE, R., Geology of Queensland, 286.
Dakyns, J. R., Glacial Phenomena of the Yorkshire Uplands, 329.
Damuda Valley Coal-fields, 32.
Dana, J. D., Award of Wollaston Medal to, 141.
Davidson, T., and W. King, Remarks on *Trimerella*, *Dinobolus*, and *Monomerella*, 442.
Davies, D. C., Overlap of Formations on the North Wales Border, 91.
—— W., On the Rostral Prolongations of *Squaloraia polyspondyla*, 145.
Dawkins, W. B., *Cervidæ* of the Forest-bed of Norfolk and Suffolk, 374; Classification of Pleistocene Strata, 374.
—— and W. A. Sanford, Pleistocene Mammalia, 327.
Dawson, J. W., Geology of Prince Edward Island, 203; Footprints from the Carboniferous of Nova Scotia, 251.
Delesse and Lapparent, "Révue de Géologie," 87.
Delta of the Nile, 479.
Deltas, Formation of, 392, 485.
Denudation, 525.
Derbyshire, Ice Scratches in, 269.
Devonian Beds, Fish-remains in the, 239.
—— Fossils from Cape Colony, 41.
—— Limestone, *Cupressocrinus* in, 387.
Devonshire, Boulder-clay (?) in, 574.
Dinobolus, 442.
Divining-rod in Somersetshire, 528; in Essex, 576.
Dominica, Geology of, 75.
Donegal, Geology of, 12.
D'Orueta, D. M., Geology of Malaga, 138.
Dover, Geology of the Straits of, 432.
Drift Deposits of Ireland, 335.
Drifts, Scotch and English, Correlation of the, 171, 189.
Duncan, P. M., *Trochocyathus anglicus* from the Red Crag, 378.
Dyer, W. T. T., On some Coniferous Remains from Solenhofen, 150, 193; On some Fossil Wood from the Lower Eocene, 241.

EARTHQUAKE in Cachar, 284; at Khabooshan, 285.
Egerton, P. de M. G., *Prognathodus Güntheri*, 236; *Ischyodus* from the Lias of Lyme Regis, 237.
Egypt, A Cry from the Land of, 479.
Endoceras proteiforme from Ambleside, 102.
Eocene, Lower, Fossil Wood from the, 241.
Essex, Divining-rod in, 576.
Eurypterus mammatus, 432.
Evans, C., Geology of Hampstead, 187.

FERNANDO NORONHA, Geology of, 42.
Ferns, Sporangia of, in the Coal-measures, 51.
Fish, Fossil, from Lyme Regis, 236.
Fish-remains in the Devonian Beds, 239.
Fisher, O., On Cirques and Taluses, 10; Greenland Meteoric Iron, 47; On a Worked Flint from the Brick-earth of Crayford, 268; Phosphatic Nodules of the Cretaceous Rocks of Cambridgeshire, 331.

"Flints, Fancies, and Facts," 39.
Flint, Worked, from Crayford, 268.
Flora, Fossil, of Great Britain, 75; of Ireland, 90.
—— of the Carboniferous Strata, 326.
Foetterle, F., Austro-Hungarian Coal Supply, 235.
Foraminifera, Eley's, from the English Chalk, 123.
——— from the Chalk of Antrim, 334.
Forbes, D., On the Geology of Donegal, 12; On Meteorites, 222.
Fossils, Mode of extracting, from Limestone, 384.
Fox, A. L., Palæolithic Implements at Acton and Ealing, 378.

GALLOWAY, W., and R. H. Scott, Colliery Explosions and Weather, 324.
Ganges, Delta of the, 494.
Gastrosacus Wetzleri, 144.
Gaudry, A., Mammalia of the Drift of Paris, 382.
Geikie, J., On Changes of Climate during the Glacial Epoch, 23, 61, 105, 164, 215, 254; Theory of the Origin of the Swedish Asar, 307.
Geological Reasoning, 572.
Geological Society of London, 41, 88, 134, 185, 236, 282, 329, 373, 569.
——— Survey of England, 132, 323, 551.
——— ——— of the United Kingdom, 192, 240.
Geologists' Association, 45, 91, 143, 187, 383, 430, 572.
Glacial Action in Canada, 330.
Glacial Beds, Correlation of the, 171, 189, 352.
Glacial Drifts of North London, 45; of the Lake District, 399.
——— Epoch, Changes of Climate during the, 23, 61, 105, 164, 215, 254.
——— ——, Changes of Sea-level during the, 392, 485.
——— Phenomena of Yorkshire, 329.
Glen Roy, Parallel Roads of, 237.
Gold-field Registry, Bendigo, 328.
Graptolites from the South of Scotland, 501, 533, 575; of the Arenig Rocks, 467; Migrations of, 185.
Gravels of Acton and Ealing, 378, 380; of Ireland, 265.
Green, A.H., on the Method of Formation of the Permian Beds of South Yorkshire, 99.
Greenland, Expedition to, 289, 355, 409, 449, 516.
——— Meteoric Iron, 47, 72.
——— Meteorites of, 88, 95.
Greensand, Upper, of Cambridge, 143, 332, 571.
Greenwood, G., Greenland Meteoric Stones, 95.
Gregory, F. T., Tin-ore in Queensland, 569.
Gunn, J., Chalk of Norfolk, 430.
Guppy, R. J. L., Visit to Dominica, 75.

HALL, J., *Psaronius* in the Devonian Rocks of New York, 463; on the Relations of the Silurian Rocks of the United States, 509.
—— T. M., Geology and Mineralogy of Lundy Island, 128.
Hampstead, Geology of, 187.
Heer, O., Fossil Plants from Kiltorkan, 134; "Flora Fossilis Arctica," 69.
Hemiaspis, 433.
Henderson, G., Notes on the Yarkand Expedition, 373.
Hicks, H., Menevian Fossils, 44; Classification of the Cambrian and Silurian Rocks, 383.
Hitchcock, C. H., Geology of New Hampshire, 126, 476.
Holl, H. B., Notes on Fossil Sponges, 309, 343.
Home, D. M., Conservation of Remarkable Boulders, 176.
Hopkinson, J., Graptolites of the Arenig Rocks, 467; On some New Species of Graptolites from the South of Scotland, 501.
Hughes, S., Obituary Notice of, 96.
——— T. M'K., Man in the Crag, 247.
——— T. W. H., Karanpura Coal-fields, India, 32.
Hulke, J. W., Ichthyosaurian Remains from Kimmeridge Bay, 42; Wealden Vertebra, 42.
Hull, E., Foraminifera of the Chalk of Antrim, 334; Drift Deposits of Ireland, 335.
Human Skeleton from a Cavern in Italy, 272, 368.
Hunt, T. S., Geognosy of the Appalachians, 76.
Hydractinia from the Coralline Crag, 337.

ICE, Age of Floating, in North Wales, 15.
Ice-sheet in North Lancashire, etc., 381.
Ice Scratches in Derbyshire, 269.
Ichthyosaurian Remains from Kimmeridge Bay, 42.
Iguanodon, 327.
Illinois, Geology of, 471.
Implements, Palæolithic, at Acton and Ealing, 378.
India, Geological Survey of, 32, 475.

Infralias in Yorkshire, 137.
Ireland, Drift Deposits of, 335; Fossil Flora of, 90; Glacial Deposits of, 110.
——— Royal Geological Society of, 90, 334.
Ischyodus, 237.

JACK, R. L., Graptolites from the South of Scotland, 575.
Jones, T. R., Devonian Fossils from Cape Colony, 41.
——— and W. K. Parker, Notes on Eley's Foraminifera from the English Chalk, 123; Cretaceous *Rotalinæ*, 136.
Jukes and Geikie, Manual of Geology, 78.
Jurassic Plants, 274.

KHABOOSHAN, Earthquake at, 285.
Kiltorkan, Fossil Plants from, 134.
Kimmeridge Bay, Ichthyosaurian Remains from, 42.
King, W., Coal-fields of India, 476.
Kingsley, C., "Town Geology," 478.
Kinahan, G. H., Middle Gravels (?), Ireland, 265.
Koenen, A. von, Mode of Extracting Fossils from Limestone, 384.
Krantz, Dr. A., Obituary Notice of, 240.

LAKE-BASINS in Norway, 481.
Lake District, Glacial Drift of the, 399; Silurian Rocks of the, 384, 481.
Lancashire, Ice-sheet in, 381.
——— West, Post-Glacial Geology of, 111, 552.
Lapworth, C., Researches in the Graptolitic Shales of Scotland, 533.
Lee, J. E., Occurrence of *Cupressocrinus* in Devonian Limestone, 387.
Le Hon, H.-S., Obituary Notice of, 192.
Leland, C. G., "Gaudeamus," 85.
Lithodomous Perforations in Derbyshire, 315.
Liverpool, Geology of, 87.
Local Museums and Scientific Societies, 46.
London Basin, Geology of the, 323, 474.
London, Geology of the Neighbourhood of, 132.
——— North, Glacial Drifts of, 45.
Lothian, East, Geology of the Coast of, 161.
Lucas, J., the Permian Beds of Yorkshire, 338.
Lundy Island, Geology and Mineralogy of, 128.
Lyell, C., "Principles of Geology," 178; "Student's Elements of Geology," 181.

MACARTNEY, J. N., the Bendigo Gold-field Registry, 328.
Mackintosh, D., the Age of Floating Ice in North Wales, 15; Calcareously-incrusted Stones in Drift, 144; Correlation of the Scotch and English Drifts, 189; Boulder-clay in Cheshire, 330; Glacial Drift of the Central Part of the Lake District, 399.
Malaga, Geology of, 138.
Mammalia of the Drift of Paris, 382.
——— Pleistocene, 327, 374.
Mammalian Remains from Acton, etc., 380; from the Norwich Crag, 431.
Man in the Crag, 247.
Marocco, Geology of, 135.
Maw, G., Geology of Marocco and the Great Atlas, 135.
Mediterranean, Physical Conditions of the, 545.
Menevian Group, New Fossils from the, 45.
Mentone, Fossil Man of, 368.
Merostomata, Fossil, 326, 433.
Meteoric Iron from Greenland, 47, 72, 516.
Meteorites, 222.
——— of Greenland, 88, 95.
Meyer, C. J. A., Wealden Formation, 282.
Micrographic Dictionary, 183.
Microscopic Structure of Rocks, 1.
Middlesex, Geology of, 132.
Midford Sands, 513.
Mineralogy of Cornwall and Devon, 96.
Minerals of Somersetshire, 129.
Mineral Veins, Origin of, 134.
Miners' Association of Cornwall and Devon, 552.
Mississippi, Delta of the, 488.
Moel-y-Tryfan, 19.
Moffat Group, Graptolites from the, 501.
Mollusca from Greenland, 411.
Monomerella, 442.
Morton, G. H., Geological Research around Liverpool, 87.

NEUES Jahrbuch für Mineralogie, etc., 560.
Newberry, J. S., Geological Survey of Ohio, 556.
New Hampshire, Geology of, 126, 476.
New South Wales, Tin-ore in, 569.
Nicholson, H. A., On the Occurrence of the Genus *Endoceras* in Britain, 102; Migrations of Graptolites, 185; Notes on some Valleys of Erosion, 318; Silurian Rocks of the Lake District, 384; on *Ortonia* and *Tentaculites*, 446.
Nicol, J., Parallel Roads of Glen Roy, 237.
Nile, Delta of the, 479.

Nordenskiöld, A. E., Greenland Meteorites, 88; Account of an Expedition to Greenland, 289, 355, 409, 449, 516.
Norfolk, Chalk of, 430.
Norway, Terraces in, 48; Valley and Lake-basins in, 481.
Nova Scotia, Reptilian Footprints in, 250, 251.

OBITUARY Notices of S. Hughes, 96; C. B. Rose, 191; H.-S. Le Hon, 192; F.-J. Pictet, 192; Dr. Auguste Krantz, 240.
Ohio, Geological Survey of, 556.
Oldham, T., Earthquake in Cachar, 284.
Orissa, Geology of, 476.
Orithopsis Bonneyi, 529.
Ortonia, 446.
Osmundites Dowkeri, 52.
Overlap of Formations, 91.
Ovibos moschatus, 327.
Owen, R., *Iguanodon*, 327.
Oxford, Geology of, 80.

PALÆONTOGRAPHICAL Society, 325.
Palæopteris Hibernica, 49.
Parallel Roads of Glen Roy, 237.
Parker, W. K., and T. R. Jones, Notes on Eley's Foraminifera from the English Chalk, 123; Cretaceous *Rotalinæ*, 136.
Pattison, S. R., Notes on the Pyrites Deposits in the Province of Huelva, in Spain, 59.
Permian Beds, Formation of the, 99.
Permian Beds of Yorkshire, 338.
Perceval, S. G., Cannington Park Limestone, 94; Denudation of the Bath Oolites, 190; Note on a Boulder near Old Cleeve, West Somerset, 177.
Phaneropleuron, 271.
Phillips, J., Geology of Oxford and the Valley of the Thames, 80.
——— J. A., Origin of Mineral Veins, 134.
Phosphatic Nodules of Cambridgeshire, 331.
Pictet, F. J., Obituary Notice of, 192.
Pinites Solenhofensis, 193.
Pitchstones of Arran, 1, 536.
Plants, Fossil, 49.
——— ——— from Kiltorkan, 134.
Plants, Jurassic, 274.
Pleistocene Strata, Classification of the, 375.
Pluvial Period, 498.
Portlock, J. E., "Rudimentary Treatise on Geology," 131.
Post-Glacial Period, Climate of the, 153.
Pothocites Grantoni, 58.
Prestwich, J., Raised Beach on Portsdown Hill, 43.
Prestwichia, 440.
Prince Edward Island, Geology of, 203.
Prognathus Güntheri, 236.
Psaronius, 463.
Purpura lapillus in the Coralline Crag, 431, 576.
Pyrites Deposits of Spain, 59.

QUATERNARY Deposits of the British Islands, etc., 262.
Queensland, Geology of, 286; Tin-ore in, 569.

RAISED Beach on Portsdown Hill, 43, 92.
Ramsay, A. C., "Physical Geology and Geography of Great Britain," 524.
——— River-courses of England and Wales, 139.
Rattray, A., Geology of Fernando Noronha, 42.
Reade, T. M., The Post-Glacial Geology of West Lancashire, etc., 111, 552.
Reclus, E., "The Earth," 34.
Red Sea, Physical Conditions of the, 545.
Reptilian Footprints in Nova Scotia, 250, 251.
Rhætic Beds of Somersetshire, 196.
Ricketts, C., On Subsidence as the Effect of Accumulation, 119.
River-courses of England and Wales, 139.
Rivière, E., Fossil Man of Mentone, 272, 368.
Robinson, W., "Flints, Fancies, and Facts," 39.
Rocks, Microscopic Structure of, 1.
Rock Staining, 389.
Rose, C. B., Obituary Notice of, 191.
Roslyn Hill Clay Pit, 403.
Rostellaria Pricei, 97.
Rotalinæ, Cretaceous, 136.

SABINE, E., Meteoric Iron in Greenland, 72.
Salisbury, Chalk Rock near, 427.
Saporta, De, Jurassic Plants, 274.
Satyrites Reynesii, 532.
Scandinavian Glacial Deposits, 62.
Scott, R. H., Heer's Flora Fossilis Arctica, 69.
——— and W. Galloway, Colliery Explosions and Weather, 324.
Scottish Glacial Deposits, 61.
Scrope, G. P., "Volcanoes," 130; Notes on the late Eruption of Vesuvius, 244.
Scudder, S. H., New Fossil Butterfly, 532.

Sea-level, Changes of, during the Glacial Period, 392, 485.
Seas, Physical Conditions of Inland, 545.
Selwyn, A. R. C., On the Discovery of Reptilian Footprints in Nova Scotia, 250.
Silurian and Cambrian Rocks, Classification of the, 383.
Silurian Rocks of the Lake District, 384, 441; of the United States, 509.
Smyth, R. B., Auriferous Deposits of Australia, 335.
Sollas, W. J., New British Crustacean, 144; Upper Greensand of Cambridge, 332.
——— and A. J. Jukes-Brown, Included Rock-fragments of the Cambridge Upper Greensand, 571.
Somersetshire, Minerals of, 129; Rhætic Beds of, 196; Divining-rod in, 528.
Sponges, Fossil, 309, 343.
Squaloraia polyspondyla, 145.
Subsidence the Effect of Accumulation, 119.
Swedish Asar, Origin of the, 307.
Swiss Glacial Deposits, 61.
Symonds, W. S., Fish-remains in the Devonian Beds of Cornwall, 239.

TALUSES, Formation of, 10, 93.
Tate, R., Note on the Discovery of the oldest known *Trigonia* in Britain, 306; "Rudimentary Treatise on Geology," 131.
Taylor, J. E., Divining-rod in Essex, 576.
Tentaculites, 446.
Terraces in Norway, 48.
Tiddeman, R. H., Evidence for the Ice-sheet in North Lancashire, etc., 381.
Tin-ore in Queensland, 569; in New South Wales, 569.
Topley, W., Geology of the Straits of Dover, 432.
Törnebohm, A. E., Origin of the Swedish Asar, 307.
"Town Geology," 478.
Traquair, R. H., Supplementary Note on *Phaneropleuron* and *Uronemus*, 271.
Tree-ferns of the Coal-measures, 465.
Trochocyathus anglicus, 378.
Trigonia Lingonensis, 306.
Trimerella, 442.
Tylor, A., on the Formation of Deltas, 392, 485.

ULRICH, G. H. F., Tin-ore in New South Wales, 569.
Unio limosus in the Crag, 431.
United States, Silurian Rocks of the, 509.
Uronemus, 271.

VALLEYS of Erosion, 318.
Valleys in Norway, 481.
Vesuvius, Eruption of, 244.
Volcanic Products, Source of, 188.
Volcanos, 130.
Volga, 495.

WALES, North, Age of Floating Ice in, 15.
Walker, H., Glacial Drifts of North London, 45.
Ward, J. C., On Rock Staining, 389.
Water, Lecture on, 477.
Wealden Vertebra, 42.
——— Formation, 282.
Whitaker, W., Geology of the London Basin, 323, 474; Occurrence of Chalk Rock near Salisbury, 427.
Whitnell, S. J., Notes on Atolls, 329.
Winkler, T. C., On *Cœlacanthus Harlemensis*, 31.
Wilson, J. M., On the Forms of Valleys and Lake-basins in Norway, 481.
Wollaston Medal and Donation Fund, Awards of the, 141.
Wood, S. V., Crag Mollusca, 326; *Purpura lapillus*, 431, 576.
——— S. V., jun., Raised Beach on Portsdown Hill, 92; On the Climate of the Post-Glacial Period, 153; Correlation of the Scotch and English Glacial Beds, 171, 352.
Wood, Fossil, from the Lower Eocene, 241.
Woodward, H., Relationship of the *Xiphosura*, 89; On a New Species of *Rostellaria* from the Grey Chalk, 97; Fossil Merostomata, 326; On a New Arachnide from the Coal-measures of Lancashire, 385; Notes on some British Palæozoic Crustacea, 433; Report on Fossil Crustacea, 563.
Woodward, H. B., List of Minerals found in Somersetshire, 129; Note on the Midford Sands, 513; The Divining-rod in Somersetshire, 528; Boulder-clay (?) in Devonshire, 574.
——— and J. H. Blake, Notes on the Relations of the Rhætic Beds to the Lower Lias and Keuper Formations in Somersetshire, 196.

XIPHOSURA, 438; Relationship of the, 89.

YARKAND Expedition, 373.
Yorkshire, Permian Beds of, 99; Infralias in, 137; Glacial Phenomena of, 329; Permian Beds of, 338.
——— Geological and Polytechnic Society of the West Riding of, 468.

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